

BIODIVERSITY OF THE WESTERN PART OF THE SOUTH CHINA SEA



**Edited by
Andrey V. Adrianov and Konstantin A. Lutaenko**

**Vladivostok Dalnauka
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A.V. Zhirmunsky Institute of Marine Biology

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**ФЕДЕРАЛЬНОЕ АГЕНТСТВО НАУЧНЫХ ОРГАНИЗАЦИЙ
ДАЛЬНЕВОСТОЧНОЕ ОТДЕЛЕНИЕ РОССИЙСКОЙ АКАДЕМИИ НАУК**

Институт биологии моря им. А.В. Жирмунского

БИОРАЗНООБРАЗИЕ ЗАПАДНОЙ ЧАСТИ ЮЖНО-КИТАЙСКОГО МОРЯ

Ответственные редакторы
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The book summarizes results of long-term biodiversity studies in the western part of the South China Sea. It contains papers of Russian, Chinese and Vietnamese authors on the composition, distribution, ecology and biogeography of reef-building corals, chitons, gastropod and bivalve mollusks, fouling, intertidal and subtidal macrophytes of Vietnam and Hainan Island. Intertidal biotic communities of Vietnam are described in detail. A historical review of marine biological studies of the A.V. Zhirmunsky Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences in the South China Sea is presented with main bibliography.

БИОРАЗНООБРАЗИЕ ЗАПАДНОЙ ЧАСТИ ЮЖНО-КИТАЙСКОГО МОРЯ. – Владивосток: Дальнаука, 2016. – 502 с.

Коллективная монография содержит результаты многолетних исследований российских, китайских и вьетнамских ученых по биоразнообразию западной части Южно-Китайского моря, в том числе статьи по составу, распределению, экологии и биogeографии рифостроящих кораллов, хитонов, брюхоногих и двустворчатых моллюсков, макрофитов обрастаний, литорали и сублиторали прибрежных вод Вьетнама и о-ва Хайнань. Подробно описаны сообщества литорали Вьетнама. Освещена история морских биологических исследований Института биологии моря им. А.В. Жирмунского ДВО РАН в Южно-Китайском море.

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Preface

This book is prepared by the A.V. Zhirmunsky Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences (IMB; Vladivostok) as an outcome of long-term collaboration of the IMB with Russian, Chinese, and Vietnamese institutions, and international organizations and networks in the fields of marine biology and biodiversity. Particularly, ideas and research findings presented in this book have been discussed during two meetings held in Nhatrang City jointly with the Institute of Oceanography, Vietnam Academy of Science and Technology (2010) and the Research Institute of Aquaculture No. 3 (2011), with financial support from the Asia-Pacific Network for Global Change Research (APN). For more than 35 years, the IMB has had a long history of research cooperation with Vietnamese and Chinese scientists on biological studies of the South China Sea. Moreover, Russian marine biologists have successfully collaborated with these Asian countries since the 1950s, resulting, in many cases, in new information on marine biological phenomena and developing biodiversity understanding. Although we do not share common seas, our environmental problems are similar, and declining biodiversity is one of the most challenging. Environmental pollution, global warming, biological invasions, coastal modifications, and overfishing all contribute to the current biodiversity crisis. The South China Sea is one of the most biodiversity-rich regions of the World Ocean, and is partially included in the East Indies Triangle (Coral Triangle), a centre of maximum marine biodiversity. However, the biodiversity of the sea has been insufficiently studied, and, therefore, every step to a better understanding is very important. In this book, we have tried to cover a wide range of marine organisms. We have invited scientists from the IMB, the Zoological Institute, Russian Academy of Sciences (St. Petersburg), Pacific Research Fisheries Centre (TINRO-centre, Vladivostok), South China Sea Institute of Oceanology, Chinese Academy of Sciences (Guangzhou), and Nha Trang Institute of Technological Research and Application, Vietnam Academy of Science and Technology (Nha Trang) to present both comprehensive reviews and research papers on the key biological groups: corals, mollusks, nemerteans, sea kraits and snakes, and

macrophytes, and also on the composition and distribution of intertidal communities. We hope that this book will be of broad interest for marine biologists in countries bordering the South China Sea and other tropical seas. Preparation and publication of the book was supported by the FEB RAS project VANT-005 (A.V. Adrianov) and the APN projects ARCP2010-18NMY and ARCP2011-10CMY (K.A. Lutaenko).

Editors

Russian biodiversity studies in the South China Sea

Over the years, almost every author who has studied one of the widespread, tropical groups has noted that there is a concentration of species in the comparatively small triangle formed by the Philippines, the Malay Peninsula, and New Guinea.

(John C. Briggs, 1974, p. 14)

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Abstract: A brief review of the Russian biodiversity studies in the South China Sea is presented with emphasis on long-term research projects conducted by specialists of the A.V. Zhirmunsky Institute of Marine Biology (IMB), Far East Branch of the Russian Academy of Sciences. The most extensive IMB studies were done in Vietnam, starting in 1980, on cnidarians (including alcyonaceans, gorgonaceans, scleractinians, hydrozoans (genus *Millepora*), and sea anemones), gastropod and bivalve mollusks, crustaceans (Isopoda, Cirripedia, Ostracoda), sipunculans, nemerteans, sea snakes, marine plants, and meiobenthic and intertidal communities. Later IMB research activities were expanded to Hainan and Hong Kong in southern China. A map of expeditions and field-works along with historical photographs are provided.

Key words: South China Sea, biodiversity, history of research, Russian contribution.

The South China Sea is one of the richest regions of the World Ocean in terms of biodiversity. The sea is partially included into the **East Indies Triangle**, a centre of maximum marine biodiversity, which includes Malaysia, the Philippines, Indonesia, and Papua New Guinea. Due to its dependence on the presence of coral reefs, this area has recently been referred to as the **Coral Triangle** (Hoeksema, 2007). S. Ekman (1953) called this triangle the **Indo-Malayan Region** and regarded it as a faunal center, from which the other tropical faunas of the Indo-Pacific recruited their species. Despite containing less than 17% of the reef area as compared to the Coral Triangle, the South China Sea hosts 571 known species of reef corals, a richness comparable to the Coral Triangle's one (Huang et al., 2015).

Russia is not a tropical country, but research interests of Russian biologists have always been directed to tropical regions. The South China Sea was of special attention due to long-term research collaboration with Vietnamese and Chinese scientists. Russian biological and particularly biodiversity explorations of the South China Sea can be subdivided into several stages and lineages:

1. The 1950–1960s joint Chinese-Soviet and Vietnamese-Soviet studies in northern Vietnam, Tonkin (Beibu) Gulf and Hainan Island, involving the *Pacific Research Fisheries and Oceanographic Institute* (TINRO, Vladivostok) and the *Zoological Institute* of the then *USSR Academy of Sciences* (ZIN, St. Petersburg) (Shuntov, 1962, 1966; Bykhovsky, 1972; and others) from Russian side; with contributions from staff members of the *Moscow State University* (e.g., Zarenkov et al., 1963), the *Far Eastern State University* (e.g., Besednov, 1969), and the then *All-Union Research Institute of Fisheries and Oceanography* (VNIRO, Moscow; e.g., Khromov, 1988). A significant contribution was made by the famous Russian zoologist and marine biologist E.F. Gurjanova (see Tzvetkova, 2004 for bibliography). Later the ZIN continued research into molluscan faunas (Sirenko, 1998, 2012; present book; Chaban, present book).

2. Marine biological studies of the *A.V. Zhirmunsky Institute of Marine Biology* (hereafter **IMB**), *Far East Branch of the Russian Academy of Sciences* (Vladivostok) (1980 up to present) in collaboration with various institutions of the Vietnam Academy of Science and Technology along the entire Vietnamese coastline. Since the late 1980s, the IMB started to collaborate with Chinese institutions to study biodiversity of the South China Sea.

3. *A.S. Severtzov Institute of Problems of Ecology and Evolution, Russian Academy of Sciences (Moscow)/Vietnamese-Russian Tropical Centre* (also in collaboration with the *Institute of Oceanology, Russian Academy of Sciences*) biodiversity studies in southern Vietnam (Britayev, Zamishliak, 1996; Pavlov et al., 2004; Lyskin, Britayev, 2005; Marin, 2006a, b; Udalov et al., 2006; Britayev, Pavlov, 2007, 2012; Prokofiev, 2008a, b; Grintsov, Poltarukha, 2010; Britayev, Mekhova, 2011; Mokievsky et al., 2011; Antokhina, Britayev, 2012; Dgebuadze et al., 2012; Kantor et al., 2012; and others).

4. *Moscow State University* marine biodiversity research in Vietnam (Zevina, 1968; Chervyakova, 2007; Chertoprud et al., 2009, 2012; Tchesunov, 2013; and others), in collaboration with other institutions.

This classification is simplified, as researchers from various institutions collaborate and publish jointly, often involving biologists from other countries. In this paper, we briefly review the studies of the IMB in the South China Sea for the last 35 years and provide major historical and bibliographical data.

The IMB administration signed an agreement on mutual research cooperation with the then Institute of Marine Research, Nha Trang (at present, Institute of Oceanography, Vietnam Academy of Science and Technology) in 1980 (Zhirmunsky, Phan, 1988b). Four projects were implemented within the framework of this agreement and later included in the project “South China Sea” of the USSR Academy of Sciences (project leaders: Prof. A.V. Zhirmunsky, former Director of the IMB, and Prof. E.A. Titlyanov). Most investigations at that time were carried out in southern Vietnam waters during coastal expeditions and cruises of the R/Vs *Kallisto*, *Akademik Alexander Nesmeyanov*, *Akademik Oparin*, and *Berill* (Fig. 1). In the 1980s, shallow-water communities of coral reefs and soft bottoms, autecology of common and commercially important invertebrates and plants, biodiversity, biochemistry and physiology were studied. Along with the IMB staff members, scientists from the Institute of Oceanology, USSR Academy of Sciences (Moscow), Paleontological Institute, USSR Academy of Sciences (Moscow), Institute of Biology of the Southern Seas, Ukrainian Academy of Sciences (Sevastopol), Pacific Institute of Geography, Far Eastern Science Center (later – Branch), USSR Academy of Sciences (Vladivostok), Far Eastern Geological Institute, Far Eastern Science Center, USSR Academy of Sciences (Vladivostok) as well as Vietnamese scientists took part in the expeditions (Figs. 2, 3). In the 1980s, three Soviet-Vietnamese marine biology symposia were held: the 1st, in April 1981, in Ho Chi Minh City; the 2nd, in March 1984, in Nha Trang; the 3rd, in March 1986, in Nha Trang (Zhirmunsky, Phan, 1988b).

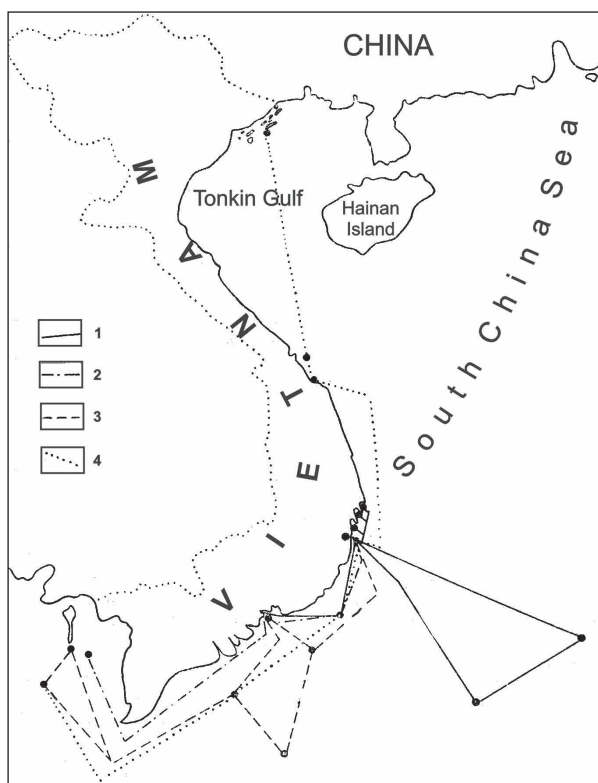
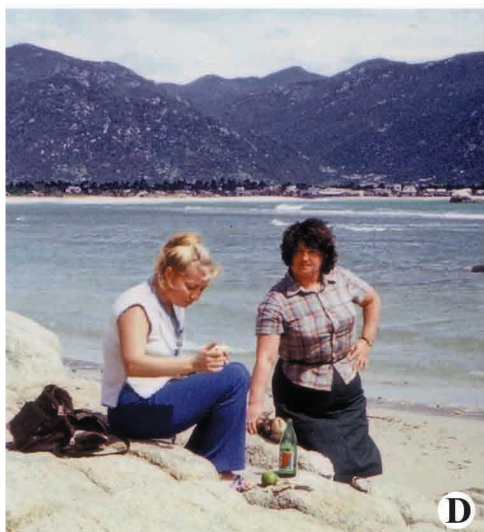


Fig. 1. A schematic map of Vietnam and adjacent areas of the South China Sea showing areas under study by the IMB in the 1981–1987 (modified after Zhirmunsky, Phan, 1988b). Dots show collecting sites; lines depict tracks of research vessels: 1 – R/V *Berill* and R/V *Kallisto*, 1981; 2 – R/V *Akademik Alexander Nesmeyanov* and R/V *Berill*, 1984; 3 – R/V *Akademik Alexander Nesmeyanov*, 1986; 4 – R/V *Akademik Alexander Nesmeyanov*, 1987.



First results of the biodiversity and marine biology studies by the IMB in the 1980s were published in three books in Russian with abstracts in English and Vietnamese (Zhirmunsky, Phan, 1988a, 1989; Kasyanov, Phan, 1989) and in a series of papers elsewhere. Three special issues of the *Soviet Journal of Marine Biology* contain papers on the biology of coastal waters of Vietnam (N 6, 1982; N 3, 1983; N 1, 1988). In the 1990s–2000s, marine biology and biodiversity studies were continued both by coastal expeditions and by use of research vessels (Fig. 4).

Coral and coral reef studies by the IMB started in 1980 in collaboration with the Institute of Oceanography VAST and the Haiphong Institute of Oceanography (Latypov, 2007). Most papers published dealt with species composition and distribution of corals, distribution of common macrobenthic species, reef communities in total, and taxonomy of scleractinian corals (Latypov, 1986, 1992, 1996a, b, 2000, 2006, 2007, 2015; Latypov, Malyutin, 1996; Latypov, Dautova, 1998; Dautova et al., 2007; and others). Malyutin and Latypov (1991) considered the biogeographical zonation of Vietnamese waters based on the composition and distribution of more than 500 species of alcyonaceans, gorgonaceans and scleractinians and found out that the coral fauna is represented solely by tropical species, and the Gulf of Tonkin area may not be separated into a biogeographic unit, and the entire Vietnamese shelf may not be zoogeographically subdivided.

In general, as a result of the 30-year studies of the reef-building scleractinians of Vietnam, 358 corals species belonging to 80 genera were found, of which 153 species in 28 genera were recorded for the first time in the area (Latypov, 2007, 2011; and others). The species diversity of Vietnam's reefs consists mainly of the members of five families: Acroporidae (98 species), Faviidae (42 species), Fungiidae (32 species), Poritidae (31 species), and Dendrophylliidae (26 species), making up altogether 64% of the total scleractinian species composition. The species composition and high diversity of Vietnamese corals are closely related to the Indonesia-Polynesian center of origin of the coral faunas (l.c.).

Malyutin (1990) and Dautova et al. (2010) described new species of the genus *Sinularia* (Octocorallia: Alcyonacea) from Vietnam.

Fig. 2. Field-works in Vietnam in the 1980s: **A** – discussions of field-work plans at the Institute of Marine Research (Institute of Oceanography), Nha Trang, Vietnam, 1979, Prof. E.A. Titlyanova (left), the then IMB Director, Prof. A.V. Zhirmunsky (right) (in center) and Vietnamese colleagues; **B** – the first coastal expedition of the IMB to Vietnam, 1981, left to right: Dr. V.E. Zhukov, Dr. Nguyen Huu Dinh, Dr. S. Sheveyko; **C** – field-works in Vietnam (1981), left to right: Dr. G. Voskoboinikov, Mr. Nguyen Nhan, Dr. Yu. Dobryakov; **D** – field-works in Vietnam (1984), left to right: Dr. T.V. Titlyanova, Dr. V.P. Gnyubkina; **E** – O Lan Lagoon, summer of 1979, left to right (sitting): Dr. Nguyen Van Chung, Prof. A.V. Zhirmunsky, the then Director of the Institute of Marine Research, Dr. Nguyen Kim Hung and a security guard.



Moshchenko (1992, 1996, 1997, 1998, 1999; Manchenko et al., 1993; and others) studied the species composition, morphology, variability, and distribution of the hydrozoans of the genus *Millepora* of Vietnam.

Sixteen species of Actiniaria belonging to 12 genera and 9 families were found on the coast of Vietnam based on the samples taken during the Russian-Vietnamese expeditions in 2007 and 2010 and on literature data; many sea anemones were hosts of anemonefishes (Kostina, 2011a).

Twenty species of peanut worms representing 11 genera and 5 families of the phylum Sipuncula were recognized from various biotopes in Nha Trang Bay (Adrianov, Maiorova, 2012). Fifteen species were new records for Nha Trang Bay with one species being a new record for the South China Sea. All species were illustrated in life with everted introvert and tentacular apparatus, and provided with descriptions, ecological data and a key up to species level (l.c.).

Chernyshev (2007, 2011) studied the nemertean (ribbon worms) fauna of Vietnam: a preliminary report contains data on 78 species collected from Co To Is. in the north to Ladd Reef in the south, and a new for science species was described. Chernyshev's paper in this book updates much earlier data. This group of animals was nearly unknown in Vietnamese waters until the above-mentioned studies.

Kussakin et al. (1990), Kussakin and Malytina (1991, 1993) and Malyutina (1995) published new data on the species composition of the isopod fauna of the South China Sea including descriptions of new species.

Cirripedes in Vietnam were studied with special respect to their role in biofouling communities of ships' hulls, hydrotechnical facilities, and oil platforms (Zevina et al., 1992; Poltarukha, Zvyagintsev, 2008). The latter book deals with the species composition, morphology and distribution of Cirripedia (superorder Thoracica) of the entire Vietnam coast, with identification keys, descriptions, and drawings of all Vietnamese species.

Ostracods of the suborder Myodocopina were studied in the waters of southern Vietnam by Chavtur (1983, 1989); he published a list of 12 species collected in the upper subtidal zone down to 30 m deep, including descriptions of four new species for science (l.c.).

Malacological research by the IMB in the South China Sea started since 1980. Gulbin and Tran Dinh Nam (1989) and Gulbin and Evseev (1997) studied intertidal prosobranch gastropods in southern Vietnam. A check-list of species collected in 9 intertidal areas (a total of 555 intertidal stations) contains 153 species of gastropods (Gulbin, Evseev, 1997); an extensive collection is stored in the IMB Museum.

Fig. 3. Field-works in Vietnam in the 1980s: **A–C** – underwater collecting in Vietnam (**A** – Dr. Yu.Ya. Latypov); **D** – Dr. Yu.Ya. Latypov sorting corals in the field; **E** – left to right: Dr. A.N. Malyutin, Dr. M.V. Malyutina; **F** – a research boat on beach; **G** – Prof. O.G. Kussakin (left) and Vietnamese fishermen.



Fig. 4. The 30th cruise of the R/V *Akademik Oparin* to the South China Sea (2005): **A** – R/V *Akademik Oparin* in the sea; **B** – trawl catch sorting aboard; **C** – Dr. V.V. Gulbin (right) with a Vietnamese colleague in a lab aboard; **D** – Dr. M.S. Selina, intertidal rocky area; **E** – collective photograph aboard; **F** – O.V. Savinova (IMB Museum) in the lab aboard.

Lutaenko (1993, 2008) and Evseev and Lutaenko (1998) analyzed the anadarine (Arcidae, Bivalvia) fauna of Vietnam based on the collections from Tonkin Gulf (Zoological Institute RAS) and southern Vietnam (stored in the IMB Museum and

the Zoological Museum of the Far Eastern Federal University). A total of 20 species were found within the fauna of Vietnam. The list of Vietnamese anadarines bears close resemblance to that of southern China and, in general, the fauna of Vietnamese anadarines can be regarded as being typical Indo-Pacific, without endemic species in Vietnam (Evseev, Lutaenko, 1998). Lutaenko (2003) additionally contributed to the check-list of marine mollusks of Vietnam.

A list of species of bivalve mollusks recorded by Russian authors for Vietnamese waters was published by Lutaenko (2000b). In total, 367 species names were enumerated, and this was the first most complete check-list of Vietnamese marine bivalves at that time. Two largest Russian collections of Vietnamese bivalves were examined: the ZIN (243 species) and the Zoological Museum, Far East Federal University (Vladivostok) (83 species); some species were provided with comments on their current taxonomic status, and a list of eleven new species described by Russian malacologists from Vietnam was compiled, with comments and full label data; photographs of the syntypes of eight species were published for the first time (l.c.). Other Russian contributions in the field of biology and ecology of Vietnamese bivalves in the 1970s–1990s were reviewed by Lutaenko (2000a).

As a result of collecting bivalve mollusks in five areas of Hong Kong in 2006, 2012, and 2013, 77 species of bivalves belonging to 22 families were identified, of which 21 species appeared to be new records for the region; taxonomy, synonymy and distribution of a number of species were discussed and commented along with biogeographic remarks on the bivalve fauna of Hong Kong in view of its location between tropical and subtropical regions (Lutaenko, Volvenko, 2013). This study showed that the bivalve fauna of Hong Kong has been only partially studied totaling now about 300 species (see a paper by Lutaenko in the present book).

Thirty-six holothurian species were sampled in the upper subtidal zone of Phukhanh Province (southern Vietnam), a new family was described, and ecological data were presented by Levin and Dao Tan Ho (1989). Another study was conducted in the open part of the South China Sea and in the Gulf of Thailand, and spatial distribution, population density, depth ranges and biotopes of holothurians were studied, with 23 species recorded (Kalashnikov, 1989). Dautov (2010) discussed the biodiversity of echinoderms in Nha Trang Bay.

The first complete check-list of the intertidal and subtidal marine algae (Rhodophyta, Chlorophyta, and Ochrophyta) of Nha Trang Bay was recently published, with a brief history of the species records in the bay between 1953 and 2010 (Titlyanov et al., 2015a). A total of 481 macroalgal taxa and their forms have been found, including 275 red, 121 green, and 85 brown algal taxa. A comparison of the collections from 1953 to 1987 and from 2002 to 2010 revealed substantial differences in species compositions. In 2002–2010 the absolute and relative numbers

of green algal species increased while those of red and brown algal species decreased and this change was likely due to increasing seawater pollution (Titlyanov et al., 2015a). Titlyanov et al. (2012) also published a review of the literature and original data on the resources, use, and cultivation of commercially important marine macrophytes in Vietnam: more than 60 species of macroalgae were included, among them 41 species of Rhodophyta, 15 species of Heterokontophyta and 7 species of Chlorophyta. According to these authors (l.c.), the wild stocks of useful algae in Vietnam are declining as a result of their uncontrolled export (especially Sargassaceae). The species composition and structure of algal fouling communities on the underwater artificial substrates at lobster farms in Nha Trang Bay (Vietnam) were studied (Titlyanov, Titlyanova 2013).

Other marine botanical diversity studies in South China Sea were devoted to Hainan Is. in southern China: research on seasonal changes in benthic algal communities of the upper subtidal zone in Sanya Bay (Titlyanov et al., 2014), data on the recent (2008–2012) seaweed flora of Hainan Is. (Titlyanov et al., 2015b), an important check-list of marine benthic green algae (Chlorophyta) in the coastal waters of Hainan Is. with comparisons between the 1930s and 1990–2009 (Titlyanov et al., 2011), and new records of benthic marine green algae (Titlyanova et al., 2012). On the basis of literature data and own sampling, an annotated account of the seaweeds of Hainan Island and nearby islets was presented by Titlyanova et al. (2014). Three sets of algal collections were involved into this study: the first series of collections by Tseng and colleagues between the 1930s and 1970s (344 species), the second collection through two German–Chinese expeditions in October–December 1990 and March–April 1992 (214 species) and the third by the authors in 2008–2012 (251 species). Historical changes in the marine flora occurred due to human impact on the main underwater ecosystem of the island–coral reefs–through irrational exploitation, eutrophication of shallow water bays with urban and marine aquaculture waste and probably by natural catastrophes such as coral bleaching events in 1998 (Titlyanova et al., 2014). This book contains two papers on the biodiversity of macrophytes in both Vietnam and southern China.

Kharin (1984, 2006; and others) studied the sea snakes of Vietnam and published an annotated check-list; a paper by Kharin and his collaborators in this book contributes much to the sea snakes' fauna of the South China Sea.

Meiobenthic studies represent an important field of the IMB research. Pavlyuk et al. (2008) were the first to study the distribution, taxonomic composition, and density of meiobenthos depending on some environmental factors in the bottom sediments of the northern estuary part of Ha Long Bay (northern Vietnam); a total of 66 species belonging to 17 families and 52 genera were identified. The estuary part

of the Ha Long Bay is constantly exposed to anthropogenic impact from the sea port (bottom dredging works), and to coastal fresh water runoff which results in significant changes of salinity within a year. In general, differences in the composition and distribution of meiobenthic communities in Ha Long Bay appeared to be connected with the changes in granulometric composition of bottom sediments, and silted sediments were characterized by low species diversity and higher density of the animals than slightly silted sands (Pavlyuk et al., 2008).

The density of meiobenthos at Nha Trang Bay reefs (southern Vietnam) shows uneven distribution and depends on the sediment type (Pavlyuk, Trebukhova, 2006). The correlation analysis revealed dependence between the median diameter of sediment particles and the density of meiobenthos. However, the taxonomic diversity of meiobenthos in Nha Trang Bay (twenty-six groups) was greater than in other areas. Nematodes dominated in bottom sediments both in Nha Trang Bay itself and at its reefs: in total, representatives of four orders, twenty-eight families and ninety-seven genera were found in Nha Trang Bay. Nematodes made up to more than 90% of the total population density of meiobenthos at stations with high number of silt particles in sediments (Pavlyuk, Trebukhova, 2006).

Special attention during marine biological investigations in Vietnam was paid to the intertidal communities (Gulbin et al., 1987; Nguyen Van Chung et al., 1988; Kostina, 2011b; and others). A hydrobiological survey carried out in 1980–1982 in southern Vietnam revealed more than 500 species of invertebrates and 67 macrophytes; the highest biomass of benthic organisms (7954 g/m^2) was registered for stony bottoms with predominance of oysters; the mean biomass was as high as 2287 g/m^2 in dry season (February–August) and 1483 g/m^2 in wet season (October–December); the intertidal zone was subdivided into three bionomic types (rocky and stony shores; dead coral reefs; sandy beaches and muddy flats) (Nguyen Van Chung et al., 1988). Kostina (2011b) studied macrobenthos taken in 1988 in the intertidal zone with mangrove vegetation of the Baytylong Archipelago, near Zanzola and Daochao islands; 53 and 38 species of macrobenthos were found in Daochao and Zanzola islands respectively. A detailed account of the intertidal communities is provided by Kostina et al. in the present book.

Subtidal macrobenthic soft-bottom communities were studied in Nha Phu Lagoon in 1981–1983 by SCUBA-diving method down to a depth of 8 m (Lukin et al., 1988). Four macrobenthic communities with nine groupings were distinguished. They were characterized with low biomass, usually less than 10 g/m^2 ; the maximum biomass (up to 375 g/m^2) was detected in the inner part of the lagoon at the margin of mangrove vegetation (l.c.).

In 2010–2011, the IMB implemented the APN (Asia-Pacific Network for Global Change Research) project, *Coastal Marine Biodiversity of Vietnam: Regional*

and Local Challenges and Coastal Zone Management for Sustainable Development (ARCP2010-18NMY and ARCP2011-10CMY) intended to study marine biological diversity in coastal zones of the South China Sea with emphasis to Vietnam, its modern status, threats, recent and future modifications due to global climate change and human impact, and ways of its conservation. The aims of the project included: 1, collection of information about overall species diversity and compilation of species lists of biota in Vietnam coastal zone as a basis for monitoring of expected changes; development of approaches for monitoring of biodiversity changes in the South China Sea; 2, documenting species diversity in island's ecosystems along the Vietnam coast as a baseline study for conserving coastal and marine biological diversity; 3, inter-comparisons of the biodiversity status in the South China Sea and adjacent regions. The project involved participants from three countries (Republic of Korea, Russia and Vietnam). In course of the project implementation, new and known data on coral reefs, meiobenthos, intertidal ecosystems, biodiversity of economically important bivalve mollusks, rare groups of animals (sipunculans, nemertines) were analyzed and summarized for the practical purposes of coastal ecosystems' management, restoration of coral reefs, and marine farming (Lutaenko, Thái, 2014). As a part of the project activities, the International Conference *Marine Biodiversity of East Asia Seas: Status, Regional Challenges and Sustainable Development* was held at the Institute of Oceanography, Vietnam Academy of Science and Technology, Nha Trang, in 2010 (Dautova, Lutaenko, 2010), and the workshop *Coastal Marine Biodiversity and Bioresources of Vietnam and Adjacent Areas to the South China Sea* was conducted at the Research Institute of Aquaculture N 3, Nha Trang, in 2011 (Lutaenko, 2011). The data obtained and summarized, and interpretations of the coastal/ecosystem changes contribute to current understanding of tropical ecosystem of the South China Sea and are partly included in the present volume.

The present book includes the results of biodiversity studies conducted by researchers from the IMB, the ZIN and Vietnamese and Chinese institutions in the coastal waters of Vietnam and Hainan Island (southern China).

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Sea kraits (Laticaudidae) and sea snakes (Hydrophiidae) of Vietnam. Taxonomy and bibliography

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Abstract: Sea kraits (Laticaudidae) and sea snakes (Hydrophiidae) reach a very high species richness in the waters of Vietnam. The morphological characteristics of the species belonging to these two groups are described. Key for identification, a checklist, taxonomical descriptions and distribution data for sea snakes of Vietnam are provided, based on the surveys of museum collections and extensive analysis of the available literature. *Laticauda laticaudata*, *Chitulia torquata diadema* and *Ch. lapemoides* are registered for the first time for Vietnamese waters. Through these surveys we also found a specimen of the rare endemic species *Hydrophis parviceps* in the Gulf of Tonkin, formerly known only from six specimens in the waters of southern Vietnam. A comprehensive bibliography of the literature on sea snakes of Vietnam is provided.

Key words: sea kraits, sea snakes, Vietnam, distribution, taxonomy, new records, bibliography.

The first information about the species composition of sea snakes of Vietnam was published in the late nineteenth and early twentieth centuries (Tirant, 1885; Mocquard, 1906) and was related to the southern areas of French Indochina (Cochinchina, Tonkin and Annam). Later on, these data were summarized in the fundamental reviews by M. Smith (1920, 1926, 1943) and R. Bourret (1934, 1936). In the second half of the twentieth century, some papers appeared in which the data on biology were supplemented with information on species composition (Barne, 1958, 1963, 1964, 1968; Shuntov, 1962, 1966; Dowling, 1966; Pickwell,

1972; Bùi Văn Du'ong, 1978) and the records of sea snake species new for Vietnamese waters (Taylor, 1963; Kharin, 1984b). Following the Bourret's work on sea snakes in former Indochina (Bourret, 1934, 1936), Barme's (1958, 1963, 1964, 1968) and Dowling's (1966) studies focused mostly on the venoms of Vietnamese sea snakes. Barme reported 13 species from Vietnam and provided detailed qualitative and quantitative data on the venom of *Lapemis curtus hardwickii* and *Enhydrina schistosa*. He did not, however, mark any distinctions between different Vietnamese species in the genus *Hydrophis* sensu lato.

Over the last 80 years the number of sea snake species recorded in Vietnam has doubled, but its waters still remain much understudied. The geographical ranges of the already documented species are poorly known and further addition of species can be expected. Moreover, the previously published studies have not been comprehensively reviewed. A recent checklist of Vietnamese sea snakes (Kharin, 2006) overlooked *Emydocephalus szczerbaki* and *Leioselasma spiralis*, two species previously reported from the country (Dotsenko, 1999, 2003, 2011), and the same publication has some shortcomings in its identification key. The latest available checklist (Nguyễn, Hó, 1996; Nguyễn et al., 2005, 2009) follows Kharin (2006), but adds no further species to the list of sea snakes recorded in Vietnam.

Kharin (2006) records 21 sea snake species for Vietnam waters. Rasmussen et al. (2011) give 25 species in their annotated list. This work deals with 28 species and assumes the finding of two species more. *Hydrophis parviceps*, the endemic of Vietnam, was found in the Gulf of Tonkin. All the earlier findings of the species were reported only for the waters of southern Vietnam.

Material and methods

The present study summarizes the results of surveys of the collections stored in the Zoological Institute of the Russian Academy of Sciences (ZISP, Russia), Pacific Fisheries Research Center (TINRO-center, Russia), Zoological Museum of the Far Eastern Federal University (ZMFEFU, Russia), Museum of the Institute of Marine Biology of the Far Eastern Branch of the Russian Academy of Sciences (MIMB, Russia), Zoological Museum of the National Museum of Natural History at the National Academy of Sciences of Ukraine, (ZMNMNH, Ukraine), American Museum of Natural History (AMNH, USA), Museum für Naturkunde Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University, Berlin (ZMB, Germany), Biozentrum Grindel, Zoologisches Institut und Zoologisches Museum der Universität Hamburg (ZMH, Germany), and the Field Museum of Natural History (FMNH, USA). Some specimens, including types, were kindly provided by colleagues from the British Museum (Natural

History) (BMNH, UK) and the Museum of Natural History of France (MNHN, France). These are abbreviations (Leviton et al., 1985) used for the collections of the museums.

The measurements and counts follow M. Smith (1926) with some alterations as described below. Scale rows were counted directly around the body (Thomas, 1976). The minimum and maximum numbers of rows are given so that they can be compared with the counts in M. Smith's research (1926).

This study adopts the system of sea snakes and sea kraits proposed by the first author (Kharin, 2005).

Key for identification

1. Nostrils and nasal scutes lateral. Internasal scutes present (Fig. 1a, b) (Family **Laticaudidae**) 2
 - Nostrils and nasal scutes dorsal. Internasal scutes absent (Fig. 1c, d) (Family **Hydrophiidae**) 4
2. Rostral divided into upper and lower portions, the upper one separating nasal *Pseudolaticauda semifasciata*
 - Rostral not divided into upper and lower portions, the upper one separating nasals 3
3. Scales in 19 rows on body. Upper lip yellow *Laticauda laticaudata*
 - Scales in 21–25 on body. Upper lip dark brown or black or cream *Laticauda colubrina*
4. Three supralabial scutes (Fig. 1e) *Emydocephalus szczyrbaki*
 - More than three supralabial scutes (Fig. 1c, d) 5

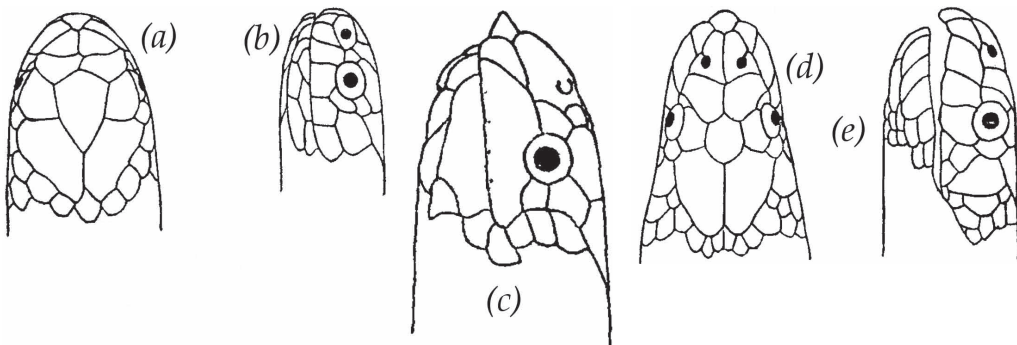


Fig. 1. Head of sea kraits and sea snakes: *Laticauda*, dorsal view (a), lateral view (b); *Emydocephalus*, lateral view (c); *Enhydrina*, dorsal view (d), lateral view (e).

5. Ventral scutes always large along whole length of body. Rostral with median sharp fold located within mouth, behind undivided lingual fossa; this fold formed from posterior edge of portion of keratinised scute extending within lining of lip *Aipysurus eydouxii*
- Ventral scutes small, slightly larger than adjacent scales, or absent. Rostral with median lobe placed at its anterior end, this lobe fitting into median notch in mental and completely dividing lingual fossa of rostral into separate left and right grooves 6
6. More than 72 scale rows around midbody *Kolpophis annandalei*
- Less than 70 scale rows around midbody 7
7. Ventrals much broader anteriorly than posteriorly (Fig. 2a, b) *Praescutata viperina*
- Ventrals, if distinct, not much broader anteriorly than posteriorly 8
8. Elongated mental scute several times longer than broad and hidden in groove (Fig. 3) *Enhydrina schistosa*
- Mental scute not much longer than broad 9
9. Spines on rear edge of some of head shields (Fig. 4) *Acalyptophis peronii*
- Not as above 10
10. Rostral divided into 4 or 5 scutes. Head scutes with thickened edges *Thalassophis anomalus*
- Not as above 11

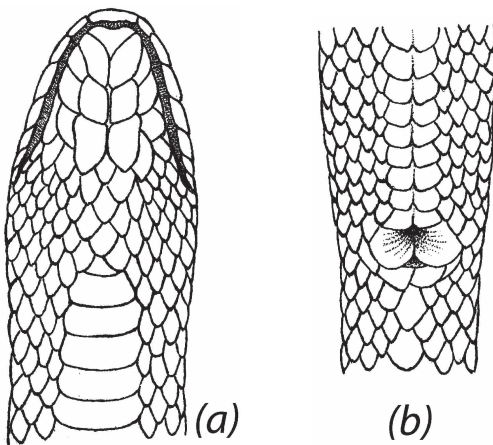


Fig. 2. *Praescutata*, ventrals. Underside views of the head (left, *a*) and the vent (right, *b*) region.

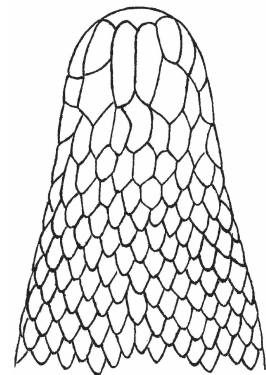


Fig. 3. Head of *Enhydrina*, ventral view.

11. Ventrals (except on throat) divided into pairs of foliiform scales (Fig. 5) *Astrotia stokesii*
 – Not as above 12

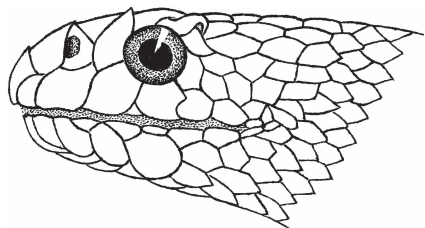


Fig. 4. Head of *Acalyptophis*, lateral view.

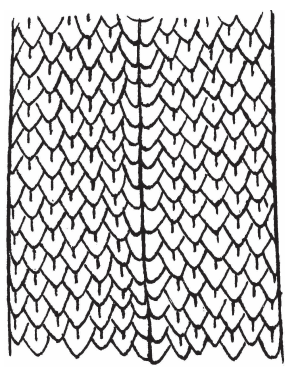


Fig. 5. Ventrals of *Astrotia*.

12. Ventrals very small and difficult to distinguish. Scales in lowermost scale rows on flanks enlarged compared to dorsal scales (Fig. 6) *Lapemis curtus hardwickii*
 – Not as above 13
13. Head elongated and slightly flattened dorsoventrally. Mouth opening (gape) very deep (Fig. 7) *Pelamis platura*
 – Not as above 14

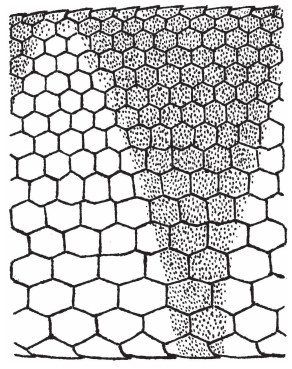


Fig. 6. Lateral view of the midbody of *Lapemis*, showing enlarged scales in the lowermost scale rows.

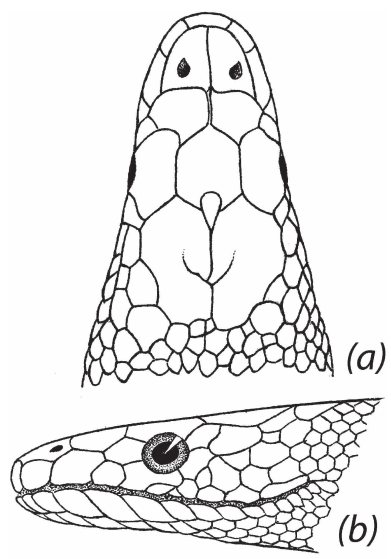


Fig. 7. *Pelamis*, dorsal view (a), lateral view (b) of the head.

14. Less than 24 scale rows around midbody *Kerilia jerdoni siamensis*
– More than 24 scale rows around midbody 15
15. At least 14 maxillary teeth behind poison-fangs
..... *Polodontognathus caeruleus hybridus*
– Less than 14 maxillary teeth behind poison-fangs 16
16. Body grey above, white below *Chitulia inornata*
– Body with bands 17
17. Body with blackish grey bands strongly dilated dorsally; tail with 3 to 5 weak
bands, tip black *Chitulia lapemoides*
– Body with blackish grey bands strongly or not strongly dilated dorsally, and/or
bands on tail not weak 18
18. Ventrals divided by longitudinal furrow posteriorly (Fig. 8)
..... *Hydrophis gracilis*
– Not as above 19
19. Less than 22 scale rows around neck
..... *Hydrophis parviceps*
– More than 22 scale rows around neck
..... 20
20. More than 31 scale rows around midtail ...
..... *Hydrophis atriceps*
– Not as above 21
21. More than 360 ventrals 22
– Less than 360 ventrals 26
22. Anterior part of *maxillare* arched upward,
so that that tip of fang nearly or quite on
line with tips of *maxillare* teeth, although fangs conspicuously longer than any
solid tooth. *Palatinum* with triangular flange articulating with anterior medial
process of *maxillare* 23
– Anterior part of *maxillare* not arched upward, tip of fang projecting conspicu-
ously below line connecting tips of solid teeth. *Palatinum* with triangular flange
for *maxillare* or with rounded or tubercle-like convexity, but never with triangu-
lare flange 24

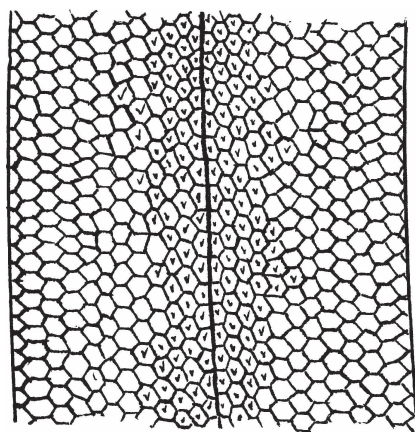


Fig. 8. Ventrals of the *Microcephalophis* subgenus of the *Hydrophis* genus.

23. *Parietale* meeting *praefrontale* to exclude *frontale* from margin of orbit and from *postorbitale* ***Hydrophis klossi***
 - *Parietale* not quite meeting *praefrontale*, so that *frontale* enters margin of orbit and makes at least point-contact with *postorbitale* ***Hydrophis brookii***
24. Tip of tail grey or olive, light bands continuing around its undersurface where evident, but in adults banding of tail and rear of body becoming less evident or even quite obsolete, without contrasting black; cross-banding more evident anteriorly than posteriorly ***Leioselasma cyanocincta***
 - Tip of tail and most or all of ventral side of tail black at all ages; dark cross-banding of adults most distinct posteriorly and on tail 25
25. Head of adult entirely yellowish, with whitish throat, dark annuli narrower than light yellowish or greenish interspaces ***Leioselasma spiralis***
 - Head of adult black, at least on sides and on throat; dark annuli may be narrower than interspaces laterally, but broader than interspaces on back; interspaces olive or grey on dorsal half of body ***Leioselasma melanocephala***
26. Neck and first third of body moderately or very narrow, cylindrical in shape. Heart located approximately at middle of body. All spines of hemipenis short (proximal spines wider than others), not longer than one half of caudal scales ***Chitulia torquata diadema***
 - Neck and first third of body wide and compressed laterally being higher than wide. Heart located in anterior third of body. Spines of hemipenis very large in proximal part, as long as caudal scales 27
27. Normally only one supralabial (fourth) bordering eye ***Chitulia belcheri***
 - Two supralabials (third and fourth) bordering eye 28
28. Most ventals more than twice as broad as adjacent costal scales. *Maxillare* with 7–8 teeth separated by diastema from fangs ***Chitulia pachycercos***
 - Ventals less than twice as broad as adjacent costal scales. *Maxillare* with 9–13 teeth separated by diastema from fangs 29
29. More than 36 scale rows around neck. Ground colour white. Body with rounded bands dorsally-anteriorly; interspaces between bands more than 2 scales ***Chitulia lamberti***
 - More than 33 scale rows around neck. Ground colour white. Body bands running parallel to each other dorsally-anteriorly; interspaces between bands less than 2 scale rows wide ***Chitulia ornata ornata***

Taxonomy

Family **Laticaudidae** M. Smith, 1926 – Sea kraits

Laticaudinae M. Smith, 1926, p. X (part.).

Maxillare extending forward beyond *palatinum*, significantly shorter than *ectopterygoideum* and loosely articulated with it so that they both can rotate upon each other in all planes (Fig. 10). Poison fangs followed after interval by one or two teeth. *Palatinum* can rotate in horizontal plane. *Praemaxillare* fixed on skull. *Dentale* with row of teeth located anterior to suture between *spleniale* and *angulare*. *Frontale* subquadrangular in outline. *Praefrontale* not in contact with *nasale* or just touching it, not in contact with *postorbitale*. *Parietale* short, broad, and flat. Nostrils and nasal scutes lateral, like in terrestrial snakes (Fig. 1a, b). Lingual valve developed from oral epithelium of inner part of rostral scute. Caudal of oar-like tail formed by cutaneous folds without bony supports, dorsal and ventral processes of caudal vertebrae not elongate. Salt excreted from nasal gland located on palate behind *praemaxillare*. Narial vestibule with rugae or papillae acting as valves. Posterior end of venom gland

curved downward behind corner of mouth (Fig. 9a). Ventrals large, one-third to more than one-half as broad as body. Subcaudals large, paired. Hemipenis with cup-shaped calyces.

Oviparous.

The family Laticaudidae comprises two genera with eight species (Heatwole et al., 2005; Kharin, 2005; Cogger, Heatwole, 2006; Kharin, Czeblukov, 2006; Kharin et al., 2010). Two species are found in Vietnamese waters (Kharin, 1983, 2006; our data).

Remarks. Sea kraits are usually regarded as a subfamily of Hydrophiidae

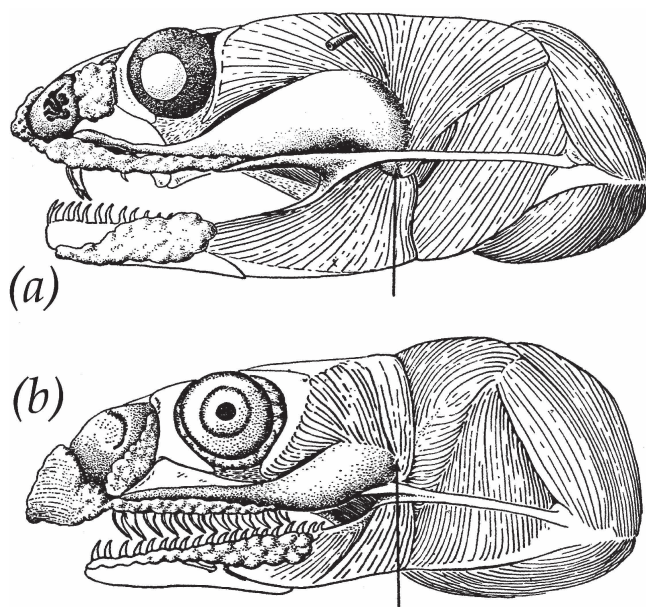


Fig. 9. Posterior pole (arrow) of the venom gland: *Laticauda colubrina* (AMNH 82462) (a) and *Kerilia jerdoni* (MCZ 23743) (b). After McDowell (1967).

s.l. (M. Smith, 1926; Kharin, 1984c) or Elapidae (McDowell, 1967, 1972; H. Smith et al., 1977; Golay et al., 1993). However, the authors of the present paper have demonstrated that differences between them are typical for families (Kharin, Czeblukov, 2006; Kharin, 2008). The elevation of this group to the level of family is based on the following characters described in the diagnoses of families: the mobility of a joint between the *maxillare* and the *ectopterygoideum*; the ability of the *palatinum* to rotate in a horizontal plane; the shape of the *praemaxillare* and its firm joint with the skull; the shape of the *nasale*; the location of the nostrils and the nasal scutes; the structure of the narial vestibule; the structure of the lingual valve; the manner in which salt is excreted; the location of the salt glands; the lengths of dorsal and ventral processes of the caudal

vertebrae; the presence of the paired subcaudal vertebrae; the structure of the hemipenis; and the mode of reproduction. It should also be noted that all these characters in sea kraits are plesiomorphous compared with the same characters in sea snakes. Therefore, sea kraits, living both on land and in water, are apparently a transitional group between terrestrial elapids and fully aquatic sea snakes.

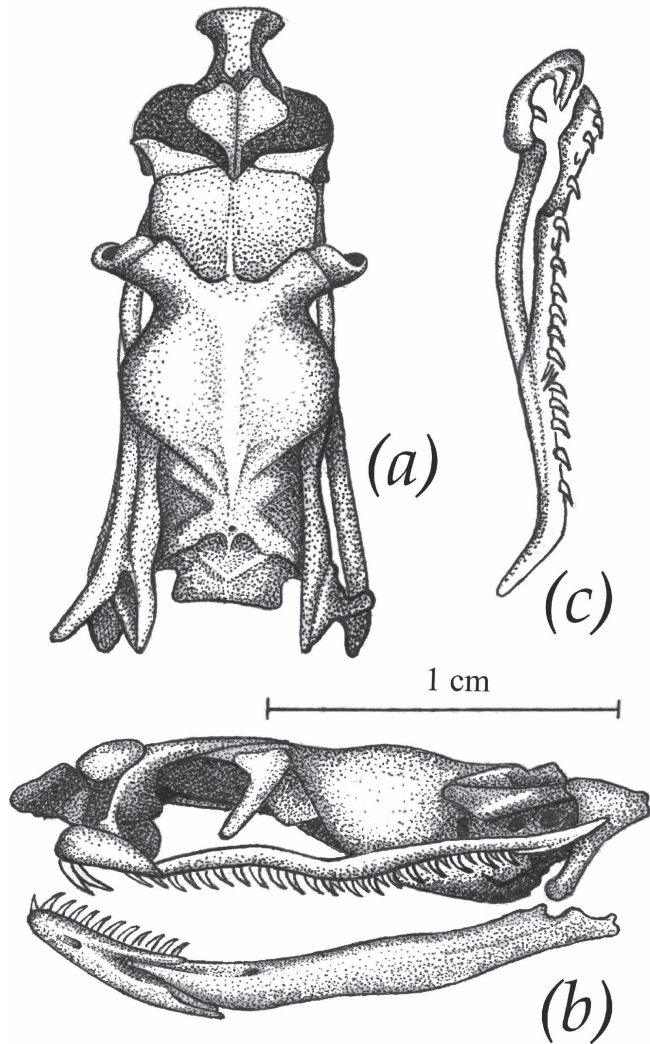


Fig. 10. Skull of *Laticauda laticaudata* (FMNH 242185). The dorsal (a) and lateral (b) views of the skull. The ventral views of *maxillare*, *ectopterygoideum*, *palatinum*, and *pterygoideum* (c). After Kharin, Czeblukov (2006).

Genus *Laticauda* Laurenti, 1768

Laticauda Laurenti, 1768, p. 109 (type *Laticauda scutata* Laurenti, 1768 = *Coluber laticaudatus* Linnaeus, 1758, by subsequent designation – Stejneger, 1907).

Platurus Latreille in Sonnini, Latreille, 1801, p. 183 (type *Platurus fasciatus* Latreille in Sonnini et Latreille, 1801 = *Coluber laticaudatus* Linnaeus, 1758, by monotypy).

D i a g n o s i s. One to two maxillary teeth present, divided by diastema from fangs. Head square in profile. *Nasale* triangular. *Parietale* broadly rounded on sides. *Praefrontale* attached to anterior margin of frontal. *Angulare* larger than *spleniale*. Neural spines of neural arches short. Tip of hemipenis with cup-shaped calyces gradually transforming into irregular-shaped spines toward base. Rostral scute undivided. Lingual valve small, developed from shallow depression. Supralabial of subocular (usually 4th) slightly wider than long. Temporals 1+2, 2+2, very rarely 2+3. Scales imbricate and smooth. Venom gland crescent-shaped, its posterior end extending below mouth corner.

The genus comprises six species.

Laticauda laticaudata (Linnaeus, 1758)

Figs. 11, 12

Coluber laticaudatus Linnaeus, 1758, p. 222 (Indiis, part.).

Laticauda scutata Laurenti, 1768, p. 109 (substitute name for *Coluber laticaudatus*).

Platurus fasciatus Latreille in Sonnini, Latreille, 1801, p. 185 (from India, Tonga-Tabu Islands, part.).

Platurus laurentii Rafinesque, 1817, p. 432 (substitute name for *Laticauda scutata*).

Platurus fischeri Jan, 1859, p. 14 (Indian Ocean).

Platurus affinis Anderson, 1871b, p. 190 (from Tolly's Nullah, a tidal stream, Calcutta, India).

Platurus muelleri Boulenger, 1896, p. 309 (South Pacific).

T y p e s. NHRM 87 (lectotype: Kharin, Czeblukov, 2006).

No azygous scute separating internasals or prefrontal scutes; one preocular and two postoculars; seven supralabials, third and fourth in contact with eye; five infralabials in contact with sublinguals, both pairs well-developed and broadly in contact with each other; series of three or four small cuneate scales at oral margin after third infralabial; temporals 1+2. Ventrals 219–252. Subcaudals 38–47 pairs (males) and 30–35 pairs (females). Altogether 19 scale rows on neck and body. Scales imbricate and smooth throughout. Snout–vent length 800 (males) and 960 mm (females). Tail length 110 (males) and 110 mm (females).

Light or dark bluish-gray above, yellowish below, with black or brown bands of more or less uniform width throughout, some or all of which may be incomplete below. Cross bands on body 26–66 in number.



Fig. 11. *Laticauda laticaudata*, lectotype of *Coluber laticaudatus*, Indiis, NHRM 87. Photo by A. Sifvergrip.

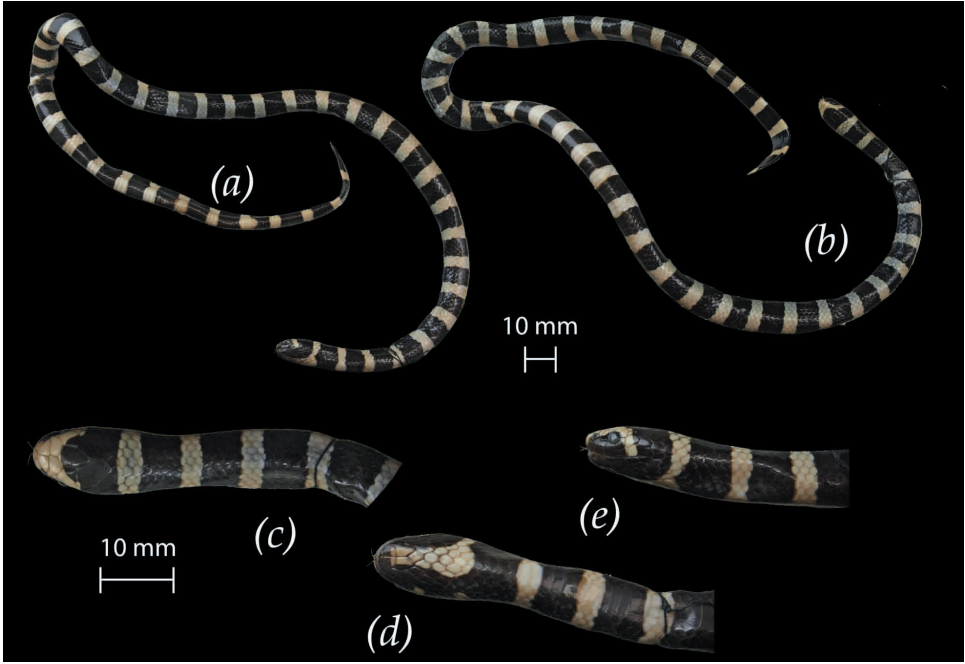


Fig. 12. *Laticauda laticaudata*, lateral view (a), dorsal view (b), dorsal head (c), ventral head (e), lateral head (g). Vietnam, Gulf of Tonkin, MIMB, not catalogued.

Distribution. The Bay of Bengal, East India, Sri Lanka, Myanmar, the Andaman Islands, Thailand, the coast of Malay Peninsula, Singapore, Indonesia (Sulawesi, Sumatra, Nias, Pulu Babi, Kalimantan, Java, Flores, Timor, Ternate, Halmahera, and the Aru Islands), the coasts of China (Fujian) and Taiwan, Japan, the Philippines, New Guinea, Australia (New South Wales, Queensland, Tasmania), Polynesia, Melanesia, the Solomon Islands, New Caledonia, and the Fiji Islands. Only one record in the waters of Vietnam (MIMB, not catalogued, Gulf of Tonkin).

***Laticauda colubrina* (Schneider, 1799)**

Figs. 13, 14

Platurus colubrinus Schneider, 1799, p. 238 (origin unknown).

Type s. ZMB 9078 (holotype).

Azygous scute separating prefrontals sometimes absent; one preocular and two postoculars; seven or eight supralabials, third and fourth in contact with eye; five infralabials in contact with sublinguals, both pairs of which usually well developed and in contact with one another; a small azygous scute usually present between anterior sublinguals and first pair of infralabials; double series of cuneate scales, lower series larger, at oral margin after second infralabial; temporals 1+2. Ventrals 213–249. Subcaudals 37–47 pairs (males) and 29–35 pairs (females). Scale rows 21–23 on neck and 21–25 on body; scales imbricate and smooth throughout. Snout–vent length 745 (males) and 1375 mm (females). Tail length 110 (males) and 110 mm (females).

Light or dark bluish-gray above, yellowish below, with black or brown bands of more or less uniform width throughout, or narrowing across belly; some or all of them may be interrupted below. Cross bands on body 24–64 in number.

Distribution. The Bay of Bengal, East India, Sri Lanka, Myanmar, the Andaman and Nicobar Islands, the western coast of Thailand and the Gulf of Thailand, Malay Peninsula, Singapore, Indonesia (Sumatra, Sulawesi, Sunda and Kalimantan, Pulu Babi, Engano, Java, Rotti, Timor, Flores, Solor, Buru, Ambon, Ternate, Halmahera, Salawatti, Kur, Kei and Aru Islands), the coasts of Taiwan, Japan (Nagasaki, Ryukyu Islands), Vietnam, the Philippines, New Guinea, Australia (New South Wales, Queensland), New Zealand, Polynesia, Melanesia, the Solomon Islands, New Caledonia, the Loyalty and Fiji Islands, the Tonga Islands, Mexico, El Salvador, and Nicaragua. Only two records in the waters of southern Vietnam (MIMB 12620, South China Sea, 12°34' N, 109°15' E; MIMB 12624, South China Sea, 12°10' N, 108°18' E).

References. Kharin (1984b, 2006); Kharin, Czeblukov (2006); Rasmussen et al. (2011).

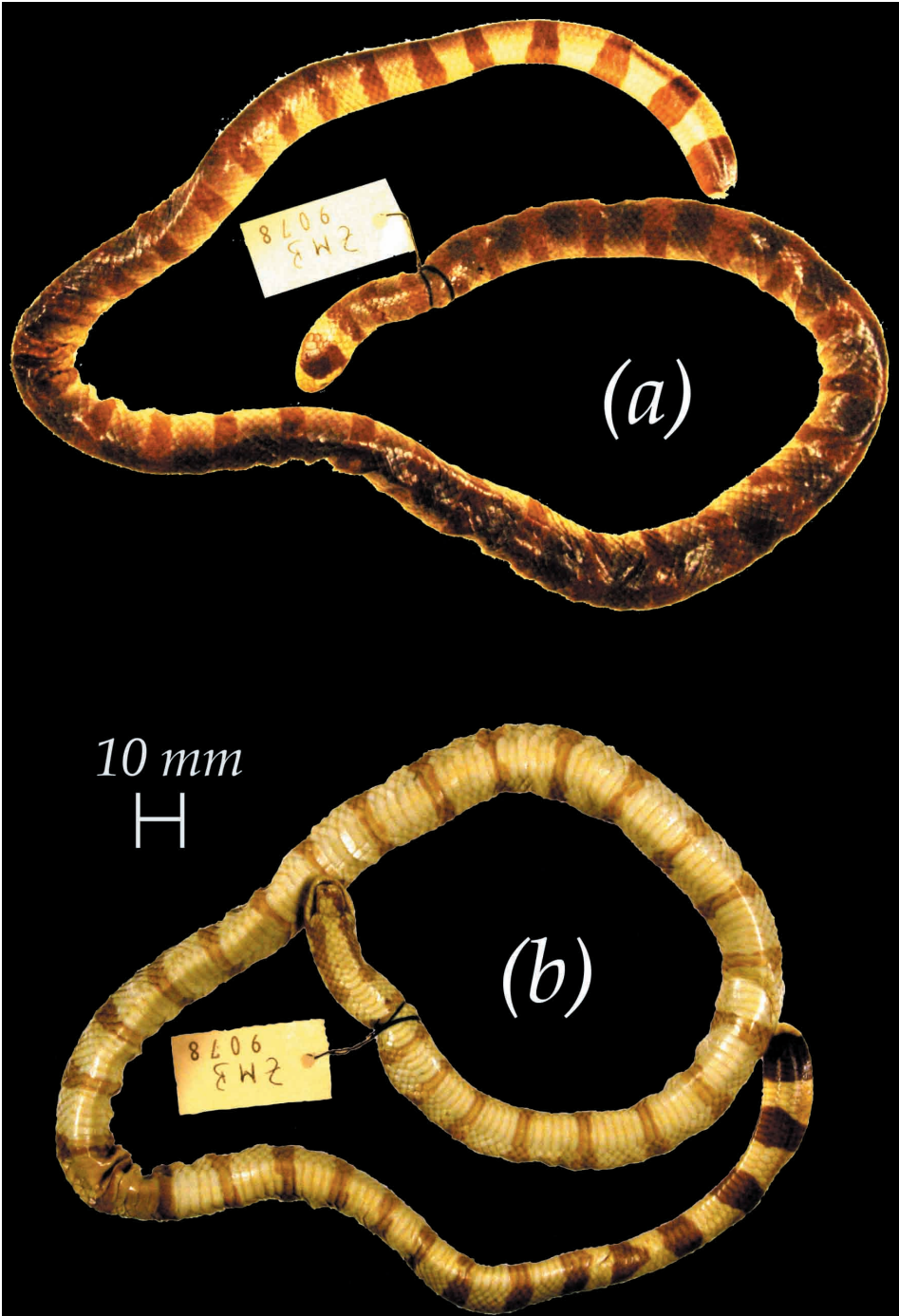


Fig. 13. *Laticauda colubrina*. The holotype. ZMB 9078.



Fig. 14. *Laticauda colubrina*. South Vietnam, MIMB 12624.

Genus *Pseudolaticauda* Kharin, 1984

Pseudolaticauda Kharin 1984c, p. 135 (type *Platurus semifasciatus* Reinwardt in Schlegel, 1837, by original designation – Kharin, 1984a).

D i a g n o s i s. One or two maxillary teeth separated by diastema from fangs. Head greatly rounded in profile; snout hardly projecting or not projecting beyond lower jaw. *Parietale* with almost straight sides; *nasale* in shape of irregular triangle; *praefrontale* attached to anterior and lateral margins of *frontale*; *angulare* equal in length to *spleniale*. Neural spines of neural archs long. Hemipenis covered with cup-shaped calyces along its full length. Rostral scute divided into two unequal parts; lower part larger, almost as long as broad. Lingual valve large, developed from posterior depression of rostral scute. Supralabial under eye (usually 5th) almost twice as broad as long; temporals 2+3. Scales imbricate and smooth. Venom gland conspicuously crescent-shaped; its lower margin so deeply indented that its posterior end bent under body of gland.

The genus comprises two species.

Pseudolaticauda semifasciata Reinwardt in Schlegel, 1837

Fig. 15

Pseudolaticauda semifasciata Reinwardt in Schlegel, 1837, p. 516 (Moluccas, Indonesia).

Type s. RMNH 1468 (the holotype).

Azygous scute separates prefrontals; one preocular and two postoculars; seven supralabials, supralabials 3 and 4 in contact with eye; five infralabials in contact with sublinguals; series of cuneate scales at oral margin after infralabials 2 and 3; temporals small, 2+3. Ventrals 195–205. Subcaudals 38–43 pairs (males) and 32–36 pairs (females). Scale rows 21–23 on neck and body. Scales strongly imbricate and quite smooth throughout. Snout–vent length 805 (males) and 1190 mm (females). Tail length 115 (males) and 115 mm (females).

Greenish or grayish or bluish above, yellowish below, with 30 to 42 complete cross bands, broader than their interspaces and usually dilated vertebrally. Head dark brownish with yellow curved mark above, connecting posteriorly with yellow band across back of head.

Distribution. The Far Eastern State Marine Reserve (Peter the Great Bay, Japan Sea), Japan (Ryukyu Islands), the Yellow Sea, the South China Sea, the coasts of China and Taiwan, the Philippines, the Lesser Sunda Islands and the Moluccas, and Indonesia (Pulu Kambing in the Lebetobi Strait, Ambon, Flores, and Java Islands).

Remarks. *P. semifasciata* was not found in the waters of Vietnam. However, according to Kharin (2009), the species is a possible new addition to the Vietnam's herpetofauna.

Family **Hydrophiidae** F. Boie, 1827 – Sea snakes

Hydrophiidae F. Boie, 1827, S. 410 (part.).

Maxillare not extending forward beyond *palatinum* (except in two species of subgenus *Microcephalophis* of genus *Hydrophis*, species of genus *Kerilia* and members of subfamily Aipysurinae), equal in length or longer than *ectopterygoideum* and firmly joins it (Figs. 16, 20). *Palatinum* may be concave, but cannot rotate horizontally. *Praemaxillare* loosely suspended from skull, so that tip of snout located opposite upper jaw. Row of teeth on *dentale* situated behind suture between *spleniale* and *angulare*. *Frontale* suboval in outline. *Praefrontale* in contact with *nasale* and in contact with *postorbitale*. *Parietale* long and narrow or subquadrangular with or without median crest. Nostrils and nasal scutes dorsal (Fig. 1c, d). Lingual valve developed from ventral margin of rostral scute. Salt excreted by posterior sublingual

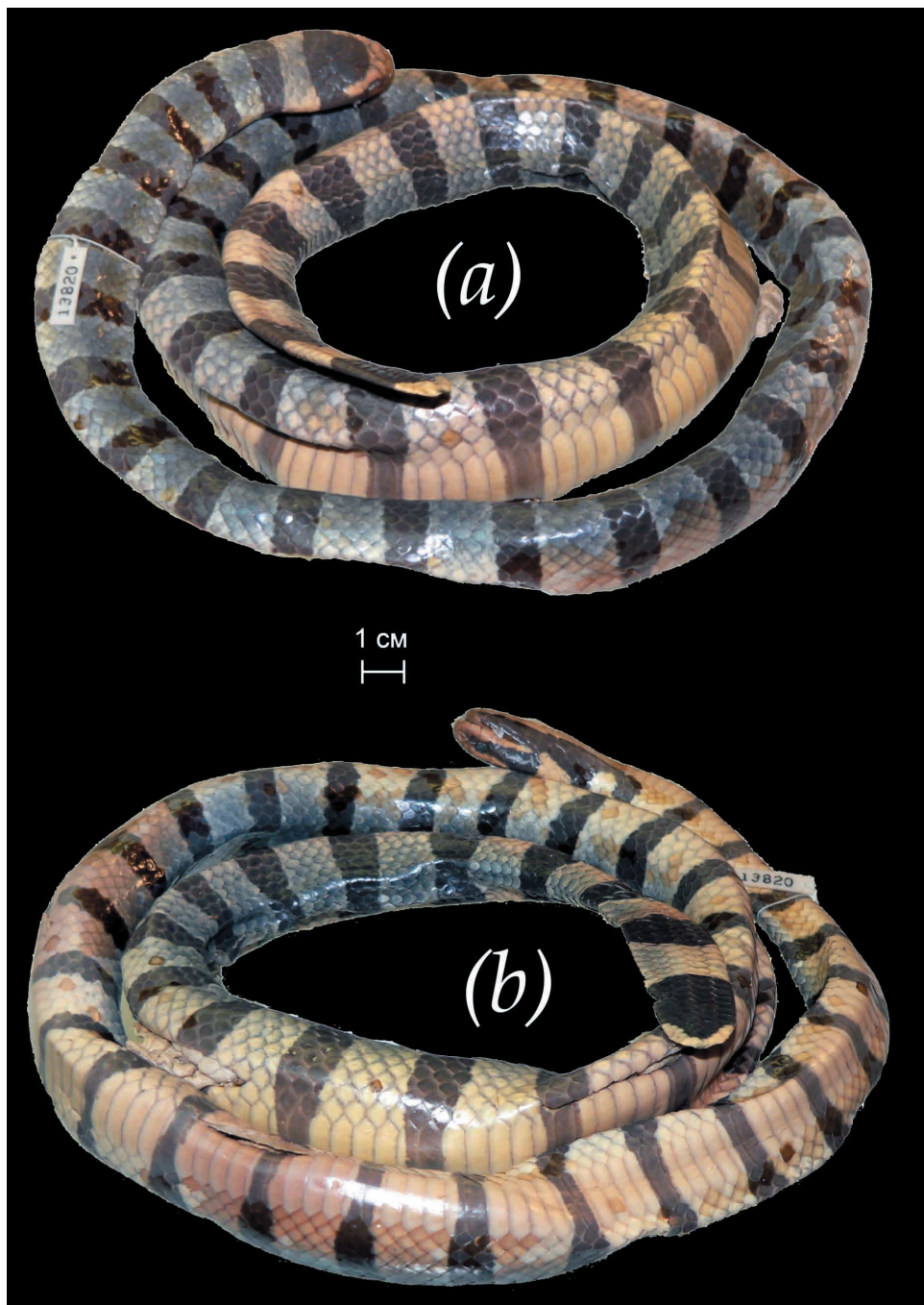


Fig. 15. *Pseudolaticauda semifasciata*. FMNH 12065, Taiwan Island. The dorsal (a) and ventral views (b). After Kharin, Czeblukov (2006).

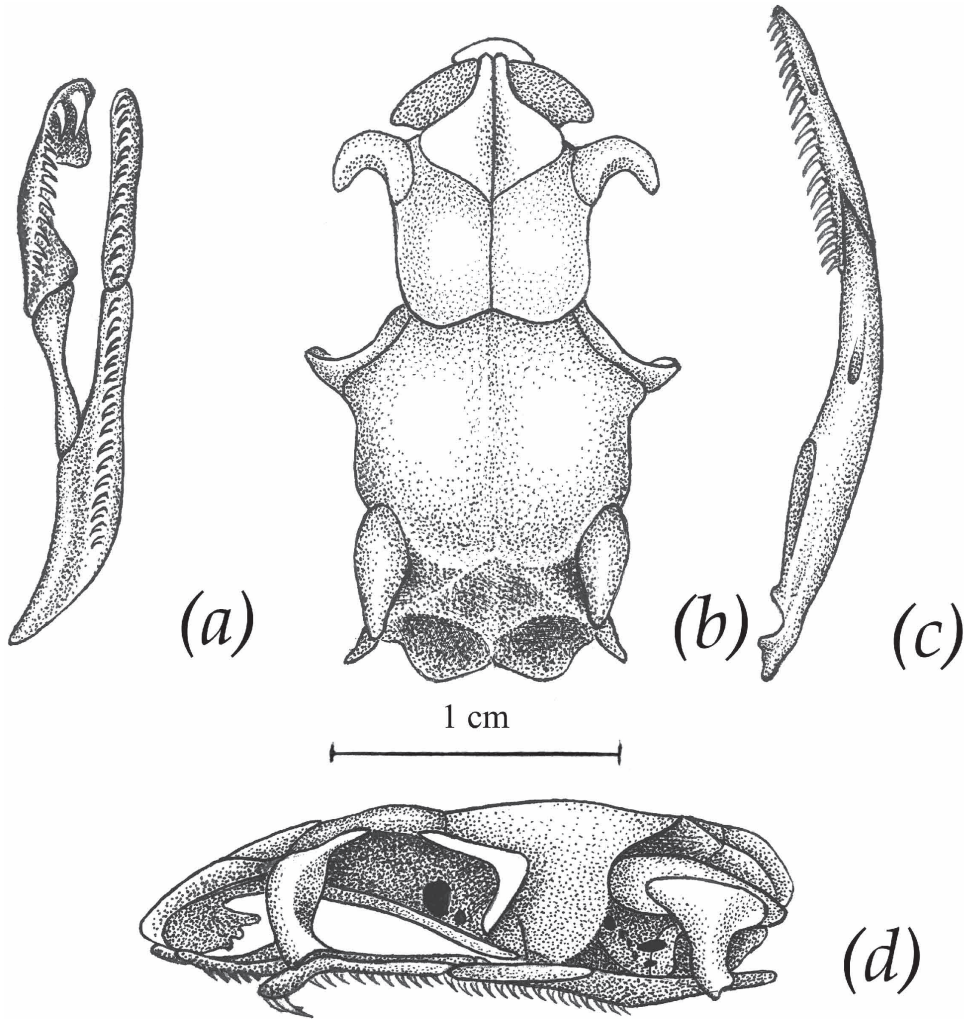


Fig. 16. Skull of *Aipysurus eydouxii* (collected by V.E. Kharin). The ventral views of *maxillare*, *ectopterygoideum*, *palatinum*, and *pterygoideum* (a). The dorsal (b) and lateral (d) views. *Dentale* (c).

gland; nasal gland absent. Narial vestibule smooth like in most snakes. Posterior end of venom gland not curved downward behind corner of mouth (Fig. 9b). Caudal vertebrae with long neural spines and elongated parpapophyses, strengthened in some species with haemal spines and hypapophyses. Ventrals large or small, or absent. Hemipenis with spines and papillae of various sizes.

Ovoviviparous.

The family includes four subfamilies.

Subfamily **Aipysurinae** Kharin, 1984

Aipysurinae Kharin, 1984, p. 136.

Maxillare extending forward beyond *palatinum* (Fig. 16). Posterior margin of superficial plate of *nasale* in contact with anterior margin of dorsal portion of *frontale*. Narrow anterior part of *frontale* squeezed between nasal and *praefrontale*; its lateral part broadly enters orbit. *Frontale* entering border orbit. *Parietale* without sagittal crest. *Basisphenoideum* without median keel. *Spleniale* without foramen. Caudal vertebrae with paired haemapophyses, but without median hypapophyses. Haemapophyses meeting to enclose canal for caudal vessels almost along full length of tail. Muscle connecting *quadratum* with fangs absent.

Heart separated from liver by more than length of liver or than length of head measured from tip of snout to jaw articulation. Areolar portion of tracheal lung only slightly extended beyond heart, halfway from heart to head. Hemipenis without liplike prominences and finger-like spines at base opposite *sulcus*, with gradually diminishing spines from middle to distal end, and with spines and papillae at its extremity.

Posterior infralabial scutes separated by small scales. Ventral always markedly large along whole length of body. Ventrals and well-expressed transverse rows of body scales correspond to vertebrae. Subcaudals unpaired. Rostral with median sharp fold located within mouth, behind undivided lingual fossa; this fold formed from posterior edge of portion of keratinised scute extending within lining of lip.

Two genera: *Aipysurus* Lacépède, 1804 and *Emydocephalus* Krefft, 1869.

Genus ***Aipysurus*** Lacépède, 1804

Aipysurus Lacépède, 1804, p. 197 (type *Aipysurus laevis* Lacépède, 1804, by monotypy).

Stephanohydra Tschudi, 1837, p. 331 (type *Stephanohydra fusca* Tschudi, 1837, by monotypy).

Hypotropis Gray, 1846a, p. 284 (type *Hypotropis jukesii* Gray, 1846 = *Aipysurus laevis* Lacépède, 1804, by monotypy).

Tomogaster Gray, 1849, p. 59 (type *Tomogaster eydouxii* Gray, 1849, by monotypy).

Pelagophis W. Peters, Doria, 1878, p. 413 (type *Pelagophis lubricus* Peters et Doria = *Aipysurus dubousii* Bavay, 1869, by monotypy).

Smithohydrophis Kharin, 1981, p. 262 (type *Aipysurus apraefrontalis* M. Smith, 1926, by original designation – Kharin, 1981), pro subgenus.

D i a g n o s i s. *Maxillare* as long as or longer than *ectopterygoideum*. Fangs after 5–17 teeth. *Palatinum* with 5–14 teeth; *pterygoideum* with 14–20 teeth; *dentale* with 12–26 teeth. *Frontale* entering border of orbit. *Parietale* meeting *frontale* to form spout-like ventral border for anterior orifice of *cavum epiptericum*. *Basisphenoideum* without median keel and excluded from margin of anterior orifice of *cavum epiptericum*. *Angularare* longer than *spleniale* or equal to it. Six to ten supralabias and six to

nine infralabial scutes. Preocular present. Diameter of eye less or equal to distance from preocular to eye corner. Two to four anterior temporals. Scales imbricate in regular rows. Ventrals large, each being at least three times as broad as adjacent body scales.

The genus comprises two subgenera (*Aipysurus* Lacépède, 1804 and *Smithohydrops* Kharin, 1981) with seven species. One species from the subgenus *Aipysurus* occurs in the waters of Vietnam.

Aipysurus eydouxii (Gray, 1849)

Figs. 17, 18

Tomogaster eydouxii Gray, 1849, p. 59 (Indian Ocean).

Thalassophis anguillaeformis P. Schmidt, 1852, S. 76. Taf. i (Java, Indonesia).

Thalassophis muraenaformis P. Schmidt, 1852, S. 77 (Java, Indonesia).

Aipysurus margaritophorus Bleeker, 1858, p. 49 (Java, Indonesia).

Type s. BMNH 1946.1.6.86 (formerly III.10.1a, holotype).

Maxillare with 7–12 teeth. Diameter of eye greater than its distance from mouth. One preocular and two postoculars; six supralabials, supralabial 4 in contact with eye; six infralabials; two anterior temporals. Scales in 15–17 rows on neck and 17 on body, 15 before vent, all imbricate and quite smooth. Ventrals 124–155, with more or less developed median keel terminating as strong spinous tubercle in adult males. Anal divided. Subcaudals 23–32. Snout–vent length 560 mm, tail length 100 mm.

Brownish or olive above, with 44–55 cross bands of yellow black-edged scales; scales often broken up on vertebral line; these bands widen towards belly; belly yellow. Head dark olive, blackish in young specimens.

Distribution. West Malaysia, the Gulf of Thailand, Vietnam, Indonesia, and Australian region. A common species in the waters of Vietnam.

References. Bourret (1934, 1936); Bùi Văn Du'ong (1978); Tran, Nguyễn (1980); Kharin (1981, 1984b); Nguyễn, Hó (1996); Dotsenko (1999, 2003); Rasmussen (2001); Nguyễn et al. (2005); Kharin (2006); Nguyễn et al. (2009); Rasmussen et al. (2011).

Genus *Emydocephalus* Krefft, 1869

Emydocephalus Krefft, 1869, p. 321 (type *Emydocephalus annulatus* Krefft, 1869, by subsequent designation – Stejneger, 1907).

Diagnosis. *Maxillare* shorter than *ectopterygoideum*, without teeth; edentulous, except for very small fangs, turned inwards. *Palatinum* and *pterygoideum* with rudimentary teeth. *Frontale* entering border of orbit. Anterior orifice of *cavum epiptericum* large and without spout-like ventral border, *basisphenoideum* forming

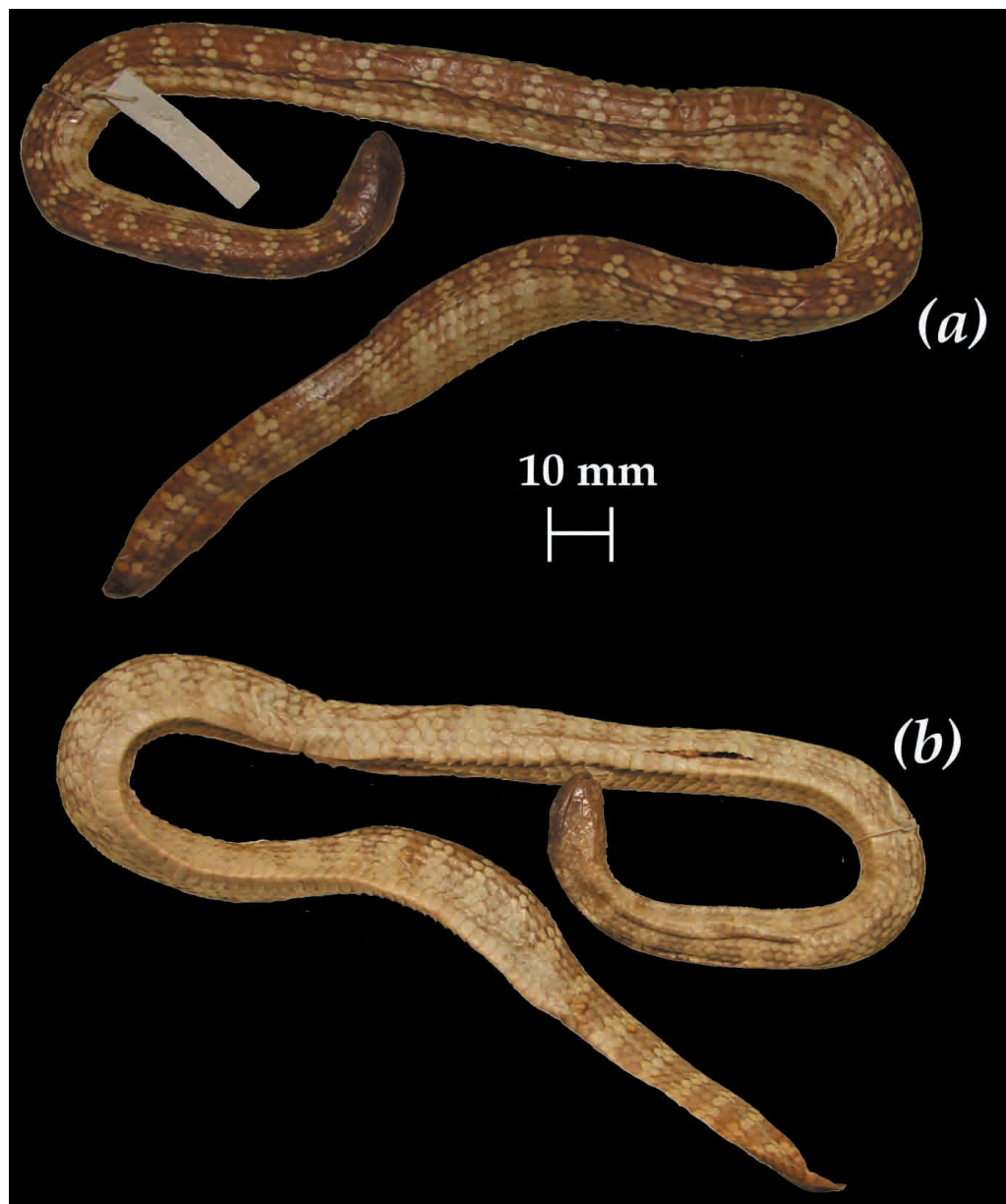


Fig. 17. *Aipysurus eydouxii*, holotype, Indian Ocean, BMNH 1946.1.6.86. The dorsal (a) and lateral (b) views. Photo by K.A. Vinnikov.

most of ventral border of orifice. *Basisphenoideum* without keel. *Angulare* larger than *spleniale* (*E. ijmae*) or equal to it (*E. annulatus*). Three supralabial and four infralabial scutes present (Fig. 1e). Supralabial 2 very long, occupying greater part of mouth

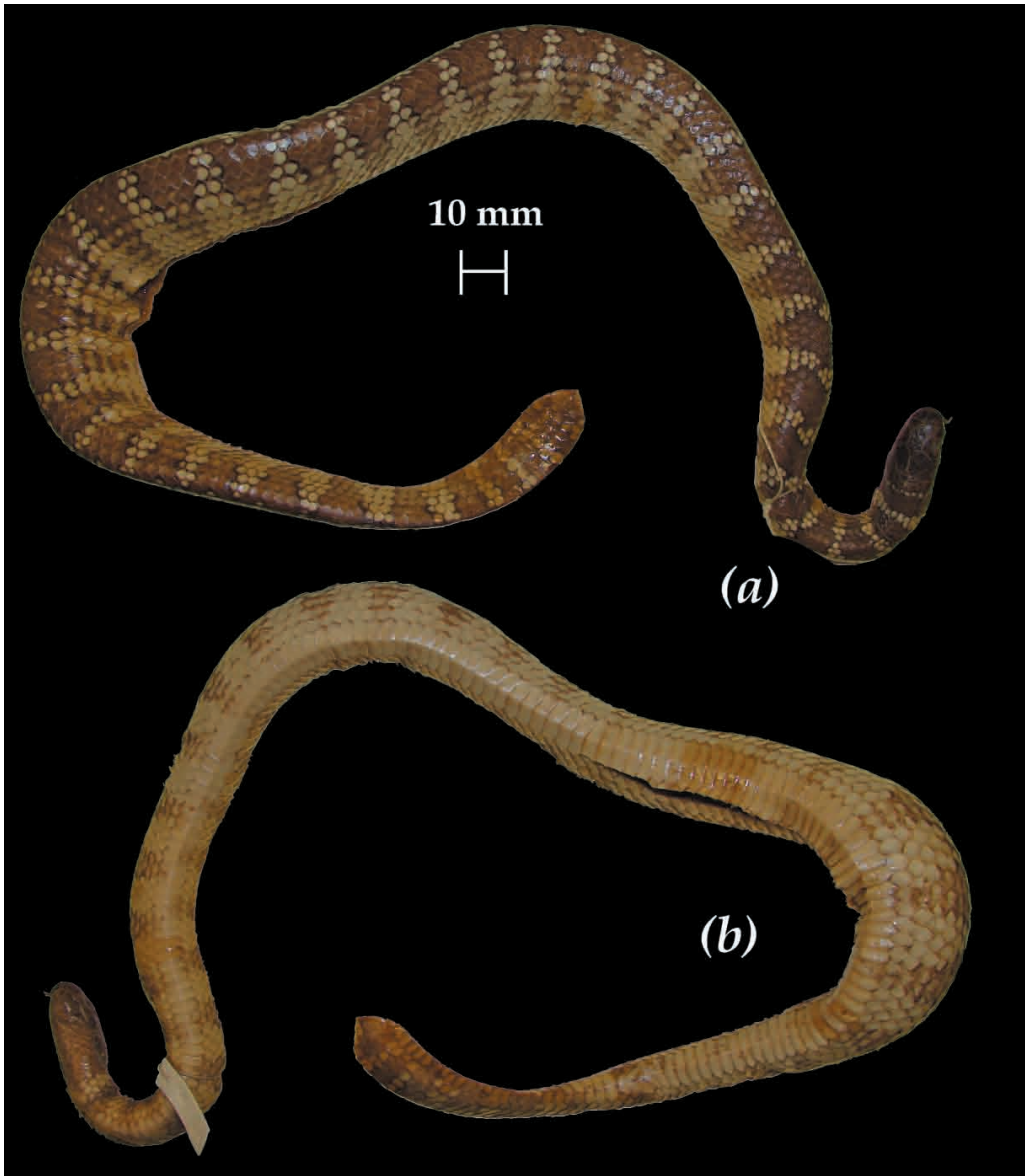


Fig. 18. *Aipysurus eydouxii*, holotype of *Aipysurus margaritophorus*, Java Island, Indonesia, BMNH 1946.1.7.1. The dorsal (a) and lateral (b) views. Photo by K.A. Vinnikov.

border. Preocular present. Diameter of eye less or equal to distance from preocular to eye corner. One to three anterior temporal scutes present. Scales imbricate throughout. Ventrals large, each being at least three times as broad as adjacent body scales.

The genus comprises three species.

Emydocephalus szczyrbaki Dotsenko, 2011

Fig. 19

Emydocephalus szczyrbaki Dotsenko, 2011, p. 131, figs. 1–5 (Vietnam, Vung Tau, Ba Ria).

Type s. ZMNMNH 27 (holotype).

Dentale with 14 very small teeth. Two prefrontal scutes, one preorbital and two postoculars; temporals small, two anterior; three supralabials and four infralabials. Scales in 15 rows on neck and body, 13 before vent, strongly imbricate throughout, vertebral row slightly enlarged. Ventrals 141 with numerous small tubercles and without median keel. Anal divided. Subcaudals 30. Snout–vent length 592 mm, tail length 105 mm.

Yellow, with 20–21 olive brown annular bands on body and 4 on tail. Head dark brown.

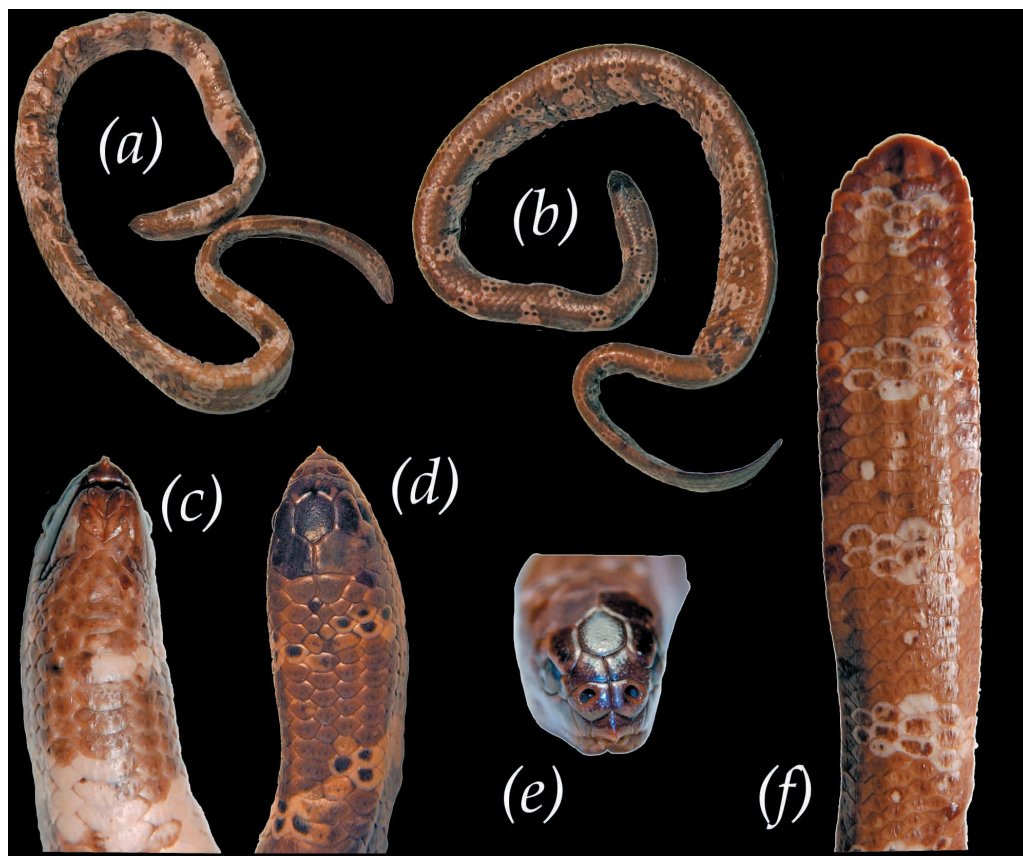


Fig. 19. *Emydocephalus szczyrbaki*, holotype, South Vietnam, ZMNMNH 27. The ventral (a) and dorsal lateral (b) views. The ventral (c), dorsal (d) and front (e) of the head and the tail (f). Photos by I.B. Dotsenko and V.I. Radchenko.

Distribution. Only single record (the holotype). The South China Sea, Ba Ria, Vung Tau.

References. Dotsenko (1999, 2003, 2011); Rasmussen, Ineich (2011); Rasmussen et al. (2011).

Subfamily **Hydrophiinae** F. Boie, 1827

Hydrophiinae F. Boie, 1827, S. 410 (part.).

Maxillare extending forward beyond *palatinum* (except in two species of the subgenus *Microcephalophis* (genus *Hydrophis*), all species of the genus *Kerilia* (McDowell, 1972; Kharin, 2004b), and members of the monotypic genus *Kerilia*). Superficial plate of *nasale* separated from dorsal portion of *frontale* by conspicuous gap characteristic for most Colubridae. *Frontale* excluded from margin of orbit. *Parietale* with sagittal crest and usually without developed lateral sharp triangular processes (except in *Praescutata viperina*). *Basisphenoidium* with median crest or without it. *Spleniale* without foramen (except in *Thalassophis anomalus*). Caudal vertebrae with very small paired hypophyses or without them, not enclosing haemal canal (except in two species of the genus *Enhydrina*), but with median hypophysial keel or process. Upper dorsal corner of *quadratum* without isolated muscle behind venom gland.

Heart separated from liver by less than half its length. Heart located in median third of body, parallel to liver. Areolar

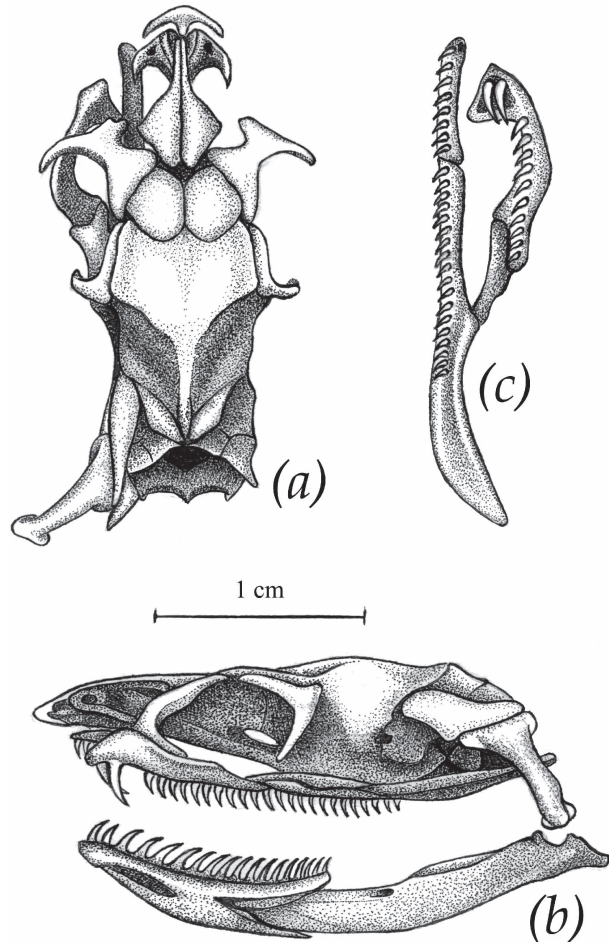


Fig. 20. Skull of *Chitulia ornata ornata* (FMNH 249193). The dorsal (a) and lateral (b) views. Ventral view of *maxillare*, *ectopterygoideum*, *palatinum*, and *pterygoideum* (c). After Kharin, Czeblukov (2006).

portion of lung generally ends halfway from heart to head (from tip of snout to jaw articulation). Hemipenis with lip-like prominences and finger-like spines at base of *sulcus*; no clear distinction between proximal spines (characteristic for Colubridae, colubroid spinose zone) and distal spines (colubroid calyculate zone). One exception is *Chitulia stricticollis*, which has regularly placed proximal spines, conspicuously shorter than distal ones. Number of ventrals and transverse body scale rows does not correspond to number of vertebrae but exceeds it; ventrals small, except in monotypic *Praescutata*, slightly larger or equal to adjacent scales, and completely absent in some highly specialised snakes like *Pelamis platura* and *Lapemis curtus* (adult specimens). Rostral with median lobe on anterior margin. This lobe fits into median notch in mental and completely divides lingual fossa of rostral into separate left and right grooves. Preocular always present (in *Enhydrina zweifeli* it may be fused with prefrontal). Posterior chin shields separated by mental groove. Anterior temporals always from one to three in number.

The subfamily comprises three tribes.

Tribe **Lapemini** Gray, 1849

Lapemina Gray, 1849, p. 43.

Depressor mandibulae without occipital head; origin of muscle confined to quadrate except for most superficial fibres that reach lateral end of transverse occipital crest. *Adductor mandibulae externus superficialis* with moderately narrow dorsal portion that leaves posterior half or more of *adductor externus medialis* exposed, *adductor externus superficialis* failing to extend backward to transverse occipital crest and not in contact with *quadratum* bone (Fig. 21d, e).

The tribe Lapemini comprises three monotypic genera: *Lapemis* Gray, 1835; *Kolpophis* M. Smith, 1926, and *Praescutata* Wall, 1921.

Genus **Praescutata** Wall, 1921

Praescutata Wall, 1921, p. 390 (types *Thalassophis viperina* P. Schmidt, 1852, by monotypy).

Thalassophina M. Smith, 1926, p. 33 (types *Thalassophis viperina* P. Schmidt, 1852, by monotypy).

D i a g n o s i s. *Maxillare* with teeth separated by diastema from fang and longer than lower aspect of *ectopterygoideum*. *Palatinum* exceeding *maxillare* in forward extent, strongly curved outward, without trace of facet or tubercle for anterior medial process of *maxillare* or *praefrontale*. *Maxillare* with 4–5 teeth, *palatinum* with 7–8 teeth, *pterygoideum* with 15–17 teeth, *dentale* with 16–17 teeth. *Parietale* broad, with strongly developed lateral wings, without median crest above. *Squamosum* scarcely projecting beyond posterior extremity of cranium. *Angulare* equal to

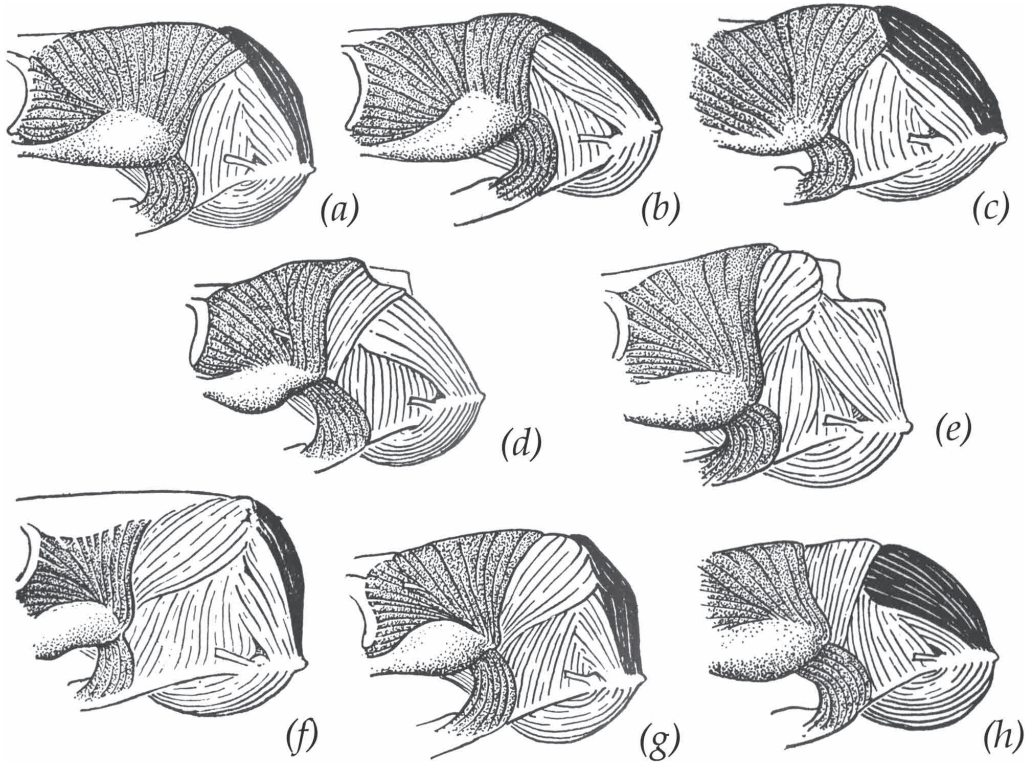


Fig. 21. Superficial head muscles of some Hydrophiinae, the *adductor externus superficialis* stippled grey, the occipital head of the *depressor mandibulae* black: (a) *Disteira kingii* (BMNH 1946.1.10.10, holotype); (b) *Enhydrina zweifeli* (AMNH 104340, holotype); (c) *Disteira major* (BMNH 1946.1.9.24, lectotype); (d) *Kolpophis annandalei* (MCZ 74093); (e) *Lapemis curtus curtus* (AMNH 76865); (f) *Hydrophis gracilis gracilis* (AMNH 90432); (g) *Chitulia lapemoides* (BMNH 1969.2902); (h) *Chitulia inornata* (BMNH 1946.1.1.27, holotype). After McDowell (1972).

spleniale, *spleniale* without foramen. *Basisphenoideum* entering border of anterior orifice of *cavum epiptericum*, with moderately developed median keel. Ventrals broad anteriorly and narrow posteriorly (Fig. 2).

The genus is monotypic.

***Praescutata viperina* (P. Schmidt, 1852)**

Figs. 22, 23

Thalassophis viperina P. Schmidt, 1852, S. 79, Taf. iii (Java, Indonesia).

Disteira praescutata Duméril, Bibron, Duméril, 1854, p. 1331 (origin unknown).

Hydrophis jayakari Boulenger, 1887, p. 408 (Muscat, Arabia).

Hydrophis plumbea Murray, 1887, p. 34 (Mekran coast, India).

Hydrophis nigra Anderson, 1872, p. 399 (Puri, Orissa, India).



Fig. 22. *Praescutata viperina*, holotype of *Disteira praescutata*, origin unknown, MNHN 6999. The dorsal (a) and ventral views (b), the scales of midbody (c) and ventral scutes (d). The dorsal (e), ventral (f) and lateral (g) views of the head. Photo by I. Ineich.

Type s. ZMH 404 (holotype. Missing type specimen (after the Second World War) – Kharin, Hallermann, 2009).

Diameter of eye about equal to its distance from mouth. One, rarely two preoculars and one or two postoculars; seven to nine supralabials, supralabials 3 and 4, or only one (fourth) or only two of them, touching eye; eight or nine infralabials; temporals variable, usually single anterior scute, but sometimes two or three. Scale rows 27–34 on neck, 37–50 on body. Ventrals 181–284, body gradually narrowing from anterior half to posterior until becoming less than twice as broad as adjacent scales. Preanal scutes considerably enlarged. Snout–vent length 826 mm (males) and 740 mm (females). Tail length 100 mm (males) and 80 mm (females).

Grey above, white below, two colours meeting on flank almost without demarcation, or dorsum grey with 25–35 dark rhomboidal bars or spots usually more or less confluent, with complete bands.

Distribution. From the Persian Gulf to southern China; the Malay Archipelago and Indonesia (Java, Kalimantan). A common species in the waters of Vietnam.

References. Mocquard (1906); M. Smith (1926, 1943); Bourret (1934, 1936); Shuntov (1962, 1966); Bùi Văn Du'ng (1978); Tran, Nguyễn (1980); Kharin

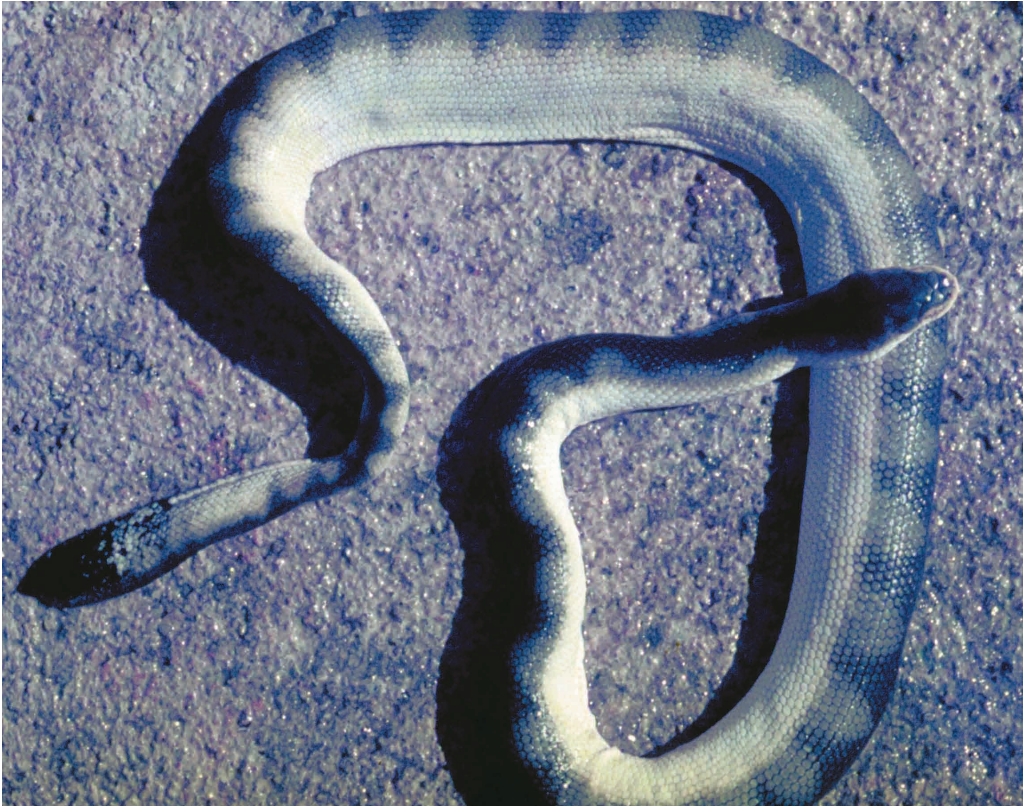


Fig. 23. *Praescutata viperina* (FMNH 201375), Mersing, Malaysia. Photo by H.K. Voris.

(1984b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Dotsenko (1999, 2003); Rasmussen (2001); Nguyễn et al. (2005); Nguyễn et al. (2009); Rasmussen et al. (2011).

Genus *Kolpophis* M. Smith, 1926

Kolpophis M. Smith, 1926, p. 106 (type *Distira annandalei* Laidlaw, 1901, by monotypy).

D i a g n o s i s. *Maxillare* with teeth separated by diastema from fang and longer than lower aspect of *ectopterygoideum*. *Palatinum* longer than *maxillare*, nearly straight, without trace of any facet or tubercle on anterior medial process of *maxillare* or *praefrontale*. *Maxillare* with 6–7 teeth, *palatinum* with 7–9 teeth, *pterygoideum* with 17–20 teeth, *dentale* with 15–16 teeth. *Angulare* equal to *spleniale*, *spleniale* without foramen. *Parietale* broad, without developed lateral wings, with median crest above. *Basisphenoideum* entering border of anterior orifice of *cavum epiptericum*. Head shields irregularly divided. Head large, body stout, covered with small irregular scales.

Monotypic genus.

Kolpophis annandalei (Laidlaw, 1901)

Fig. 24

Distira annandalei Laidlaw, 1901, p. 579, fig. (Pattani Bay, Thailand).

Type s. BMNH 1946.1.17.56 (formerly 1926.10.18.1, holotype).

Diameter of eye equal to or slightly less than its distance from mouth. Nasal and prefrontal scutes usually divided; supraoculars, frontal, and parietals usually entire. Nine to eleven supralabials, subject to much fragmentation. Infralabials when defined usually separated from oral margin by cuneate scales. Temporals small and irregular. Usually no distinct sublinguals. Scale rows 62–82 on neck, 74–93 on body, those posterior more or less hexagonal in shape, subimbricate to juxtaposed, smooth, or with short keel. Ventrals 320–369, distinct throughout. Preanal scutes considerably enlarged. Snout–vent length 790 mm and tail length 120 mm.

Yellowish and pale grey with 35–45 dorsal bars, much broader than their interspaces and tapering to point on sides; or with dorsum entirely grey; below whitish. Head olivaceous.

Distribution. Malaysia (Peninsular), the Gulf of Thailand, Singapore, southern Vietnam, Brunei, Indonesia (Java, Kalimantan). A common species in the waters of southern Vietnam.

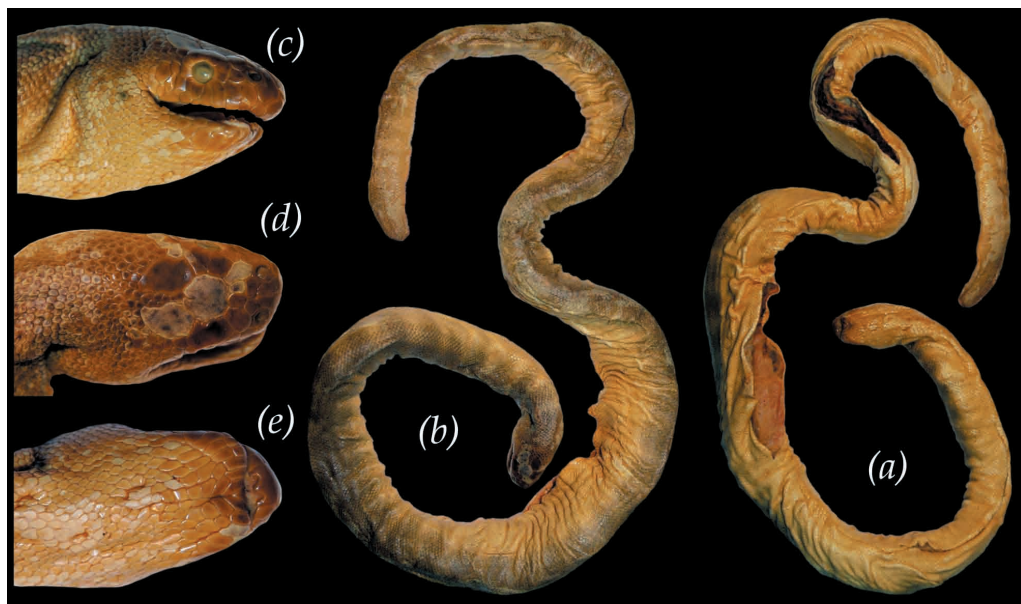


Fig. 24. *Kolpophis annandalei* (ZMNMNH 1910/4694), South Vietnam. The ventral and (a) dorsal lateral (b) views. The lateral (c), dorsal (d) and ventral (e) views of the head. Photos by I.B. Dotsenko and V.I. Radchenko.

References. M. Smith (1926, 1943); Bourret (1934, 1936); Bùi Văn Du'ong (1978); Tran, Nguyễn (1980); Kharin (1984b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Dotsenko (1999); Nguyễn et al. (2005); Nguyễn et al. (2009); Rasmussen et al. (2011).

Genus *Lapemis* Gray, 1835

Lapemis Gray, 1835, pl. lxxxvii, color fig. (type *Lapemis hardwickii* Gray, 1835, by monotype and original designation).

Diagnosis. *Maxillare* with teeth separated by diastema from fang, longer than lower aspect of *ectopterygoideum* extending forward as far as *palatinum*. *Palatinum* straight. *Maxillare* with 2–6 teeth, *palatinum* with 5–7 teeth, *pterygoideum* with 19–22 teeth, *dentale* with 12–16 teeth. *Frontale* narrowly articulating with *postorbitale*. *Parietale* with sagittal crest, without developed sharp triangular processes on sides, and with median crest ventrally. *Angulare* equal to *spleniale*. *spleniale* without foramen. *Basisphenoideum* without median keel and not entering anterior orifice of *cavum epiptericum*.

Parietal scutes entire or divided into irregular scutes. Scales hexagonal or squarish, juxtaposed, lowermost three or four rows larger than others. Scale rows 23–31 on neck in males, 27–35 in females; 25–39 scale rows on midbody in males, 33–43 in females. Ventrals small in young specimens, not exceeding adjacent scales in size; in adult specimens ventrals absent.

One species with two subspecies.

Lapemis curtus hardwickii (Gray, 1835)

Figs. 25, 26

?*Hydrophis flaviventris* Siebold, 1827, p. 142 (Japan, *nomen dubium*).

Lapemis hardwickii Gray, 1835, pl. lxxxvii, color fig. 2 (India).

Hydrophis pelamidoides Schlegel, 1837, p. 512, pl. xviii (Indian Seas).

Lapemis loreatus Gray, 1843, p. 46 (?Borneo = Kalimantan, Indonesia).

Hydrophis (Pelamis) pelamidoides var. *annulata* Fischer, 1856, S. 67, Taf. iii (Java, Indonesia).

Hydrophis problematicus Jan, 1859, p. 25 (Manila, Philippines).

Hydrophis abbreviatus Jan, 1863 p. 109 (Manila, Philippines).

Hydrophis brevis Jan, 1863, p. 109 (Manila, Philippines).

Type s. BMNH 1946.1.18.39 (formerly III.2.2a, holotype).

Diameter of eye about equal to its distance from mouth. Parietal scutes entire; one preocular and one or two postoculars; seven or eight supralabials, sometimes third and fourth in contact with eye; eight or nine infralabials; two, rarely three, anterior temporals. Scale rows 23–31 on neck in males, 27–35 in females; 25–37 scale rows on midbody in males, 33–41 in females, not as large as adjacent scales

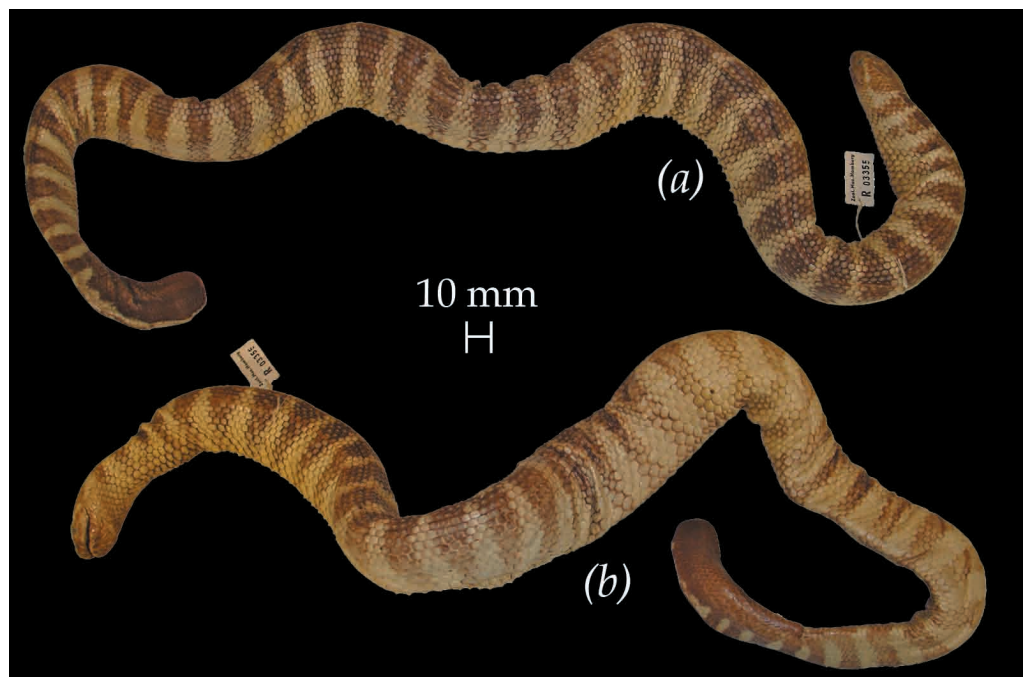


Fig. 25. *Lapemis curtus hardwickii*, holotype of *Hydrophis pelamidoides* var. *annulata*, Java, ZMH R03355. After Kharin, Hallermann (2009).



Fig. 26. *Lapemis curtus hardwickii* (FMNH 20217), Sungai Buloh, Malaysia. Photo by H.K. Voris.

except quite anteriorly, frequently absent altogether, uni- or bituberculate. Ventrals 114–186 in males and 141–230 in females. Scales hexagonal or squarish, lower-most rows with central tubercle or short keel, which in adult males may become strongly spinose. Preanals feebly enlarged. Snout–vent length 775 mm and tail length 85 mm.

Greenish or yellowish olive above, whitish below, with from 35 to 50 pale olive to dark grey dorsal bars which taper to point on sides. Dorsal bars may be continued around body as complete bands; narrow dark ventral stripe may be present, or, less frequently, broad irregular band.

Distribution. From the Mergui Archipelago to southern Japan and the coasts of Australia and New Caledonia. A common species in the waters of Vietnam.

Remarks. Separation of the species *L. hardwickii* from *L. curtus* (Boulenger, 1896; Wall, 1921; McDowell, 1972) is currently believed to be pointless (Gritis, Voris 1990). Some authors (Burger, Natsuno, 1974; Golay et al., 1993; Kharin, Hallermann, 2009) consider that the Pacific populations represent a distinct subspecies.

References. Mocquard (1906); M. Smith (1926, 1943); Bourret (1934, 1936); Shuntov (1962, 1966); Pickwell (1972); Bui Văn Du'ong (1978); Tran, Nguyễn (1980); Kharin (1984b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Dotsenko (1999, 2003); Rasmussen (2001); Nguyễn et al. (2005); Kharin (2006); Nguyễn et al. (2009); Rasmussen et al. (2011).

Tribe **Hydrophiini** F. Boie, 1827

Depressor mandibulae with strong occipital head, originating from transverse occipital crest near midline, its fibres passing posterior to those of quadrate head of *depressor mandibulae*. *Adductor mandibulae externus superficialis* moderately narrow, leaving posterior portion of *adductor externus medialis* exposed; origin of *adductor externus superficialis* confined to transverse occipital crest or to level of *quadratum* bone (Fig. 21f, g, h) .

The tribe Hydrophiini comprises eight genera: *Acalyptophis* Duméril, 1854; *Pelamis* Daudin, 1803; *Thalassophis* P. Schmidt, 1852; *Kerilia* Gray, 1849; *Polyodontognathus* Wall, 1921; *Leioselasma* Lacépède, 1804; *Chitulia* Gray, 1949, and *Hydrophis* Latreille in Sonnini et Latreille, 1801.

Genus **Kerilia** Gray, 1849

Kerilia Gray, 1849, p. 57 (type *Kerilia jerdonii* Gray, 1849, by monotypy).

Diagnosis. *Maxillare* conspicuously extending beyond *palatinum*, although fang is not far in advance of the *maxillare-praefrontale* articulation. *Maxillare* with 7–11 teeth, *palatinum* with 7–9 teeth, *pterygoideum* with 12–17 teeth, *dentale* with

18–20 teeth. Fangs either followed directly by *maxillare* teeth without intervening diastema. *Maxillare–ectopterygoideum* articulation with less expressed overlap than in other Hydrophiidae, *ectopterygoideum* not extending forward over dorsal surface of *maxillare* past last *maxillare* tooth. *Palatinum* straight, with small, but distinct and rounded hill-like prominence for anterior medial process of *maxillare*; facet of *maxillare* well anterior to middle of *palatinum*. *Basisphenoideum* nearly or quite excluded from border of anterior orifice of *cavum epiptericum*, with sharp but rather low keel along midline. *Postorbitale* meeting *praefrontale*, but *parietale* usually narrowly separated from *praefrontale* by *frontale*. *Quadratum* extending straight downward without backward inclination. *Spleniale* without foramen.

The genus is monotypic, with two subspecies.

Kerilia jerdonii siamensis M. Smith, 1920

Fig. 27

Kerilia jerdonii siamensis M. Smith, 1920, p. 28 (Pattani Bay, Thailand).

Type s. BMNH 1946.1.1.85 (formerly 1926.5.28.29, holotype).

Diameter of eye equal to its distance from mouth. One preocular and one postocular. Six supralabials; last one often confluent with single anterior temporal; supralabials 3 and 4 in contact with eye; seven or eight infralabials. Anterior temporal single. Scale rows 17 on neck and 21–23 on middle body; scales broader than long, imbricate throughout and strongly keeled. Four infralabials in contact with

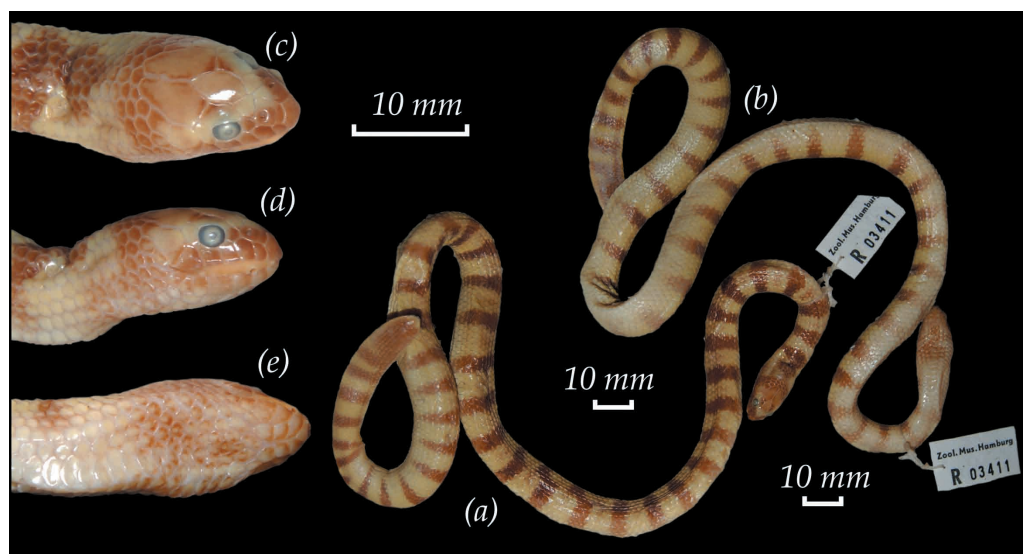


Fig. 27. *Kerilia jerdonii* (ZMH 03411), Penang, West Malaysia. Photo by J. Hallermann.

sublinguals. Ventrals 212–253, distinct throughout, slightly broader than adjacent scales. Snout–vent length 840 mm; tail length 100 mm.

Olive above, yellowish or white beneath, with from 38 to 50 black dorsal spots or rhombs around middle body.

Distribution. Malaysia (eastern Peninsula and Sabah), eastern Thailand, Vietnam, Taiwan. A common species in the waters of Vietnam.

Remarks. Two subspecies are recognised (M. Smith, 1926): *K. jerdoni jerdoni* is found in India, Sri Lanka, the Andaman Sea, and from the Strait of Malacca to Singapore; *K. j. siamensis* is found from East Malaysia, the Gulf of Thailand to China and Taiwan (M. Smith, 1926; Rasmussen, Andersen, 1990).

References. M. Smith (1926, 1943); Bourret (1934, 1936); Tran, Nguyễn (1980); Kharin (1984b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Nguyễn et al. (2005); Nguyễn et al. (2009); Rasmussen et al. (2011).

Genus *Acalyptophis* Boulenger, 1896

Acalyptus Duméril, 1853, p. 522 (type *Acalyptus peronii* Duméril, 1853, by monotypy), *nomen praeocupatum* (non Schoenheer, 1836, Coleoptera).

Acalyptophis Boulenger, 1896, p. 269 (substitute name for *Acalyptus*).

Pseudodistira Kinghorn, 1926, p. 71 (type *Pseudodistira horrida* Kinghorn, 1926 = *Acalyptophis peronii* (Boulenger, 1896), by monotypy).

Diagnosis. *Palatinum* extending beyond *maxillare*, without facet for *maxillare*, distinctly arched outward anteriorly. *Maxillare* with 5–10 teeth separated by diastema from fangs. *Palatinum* with 8–10 teeth, *pterygoideum* with 20–24 teeth, *dentale* with 22–23 teeth. *Parietale* and *postorbitale* meeting *praefrontale* to exclude *frontale* from margin of orbit. *Palatinum*–*pterygoideum* articulation well posterior to *maxillare*–*praefrontale* articulation with anterior medial process, but anterior to *maxillare*–*ectopterygoideum* articulation. *Basisphenoideum* with feeble median keel, entering border of anterior orifice of *cavum epiptericum*. *Quadratum* vertical. *Spleniale* without foramen. Frontal and parietal scutes broken up irregularly, prefrontal scutes probably absent, nasal scutes variably fragmented, but always broken into anterior and posterior portions, in contact at least on midline of snout. Scales around eye forming horn-like and projecting spines.

The genus is monotypic.

Acalyptophis peronii (Duméril, 1853)

Fig. 28

Acalyptus peronii Duméril, 1853, p. 522 (New Holland = Australia).

Acalyptus superciliosus vel peronii Duméril, Bibron, Duméril, 1854, p. 1340 (name not binominal).

Pseudodistira horrida Kinghorn, 1926, p. 71, pl. and fig. (McCulloch Reef, Great Barrier Reef, Australia).

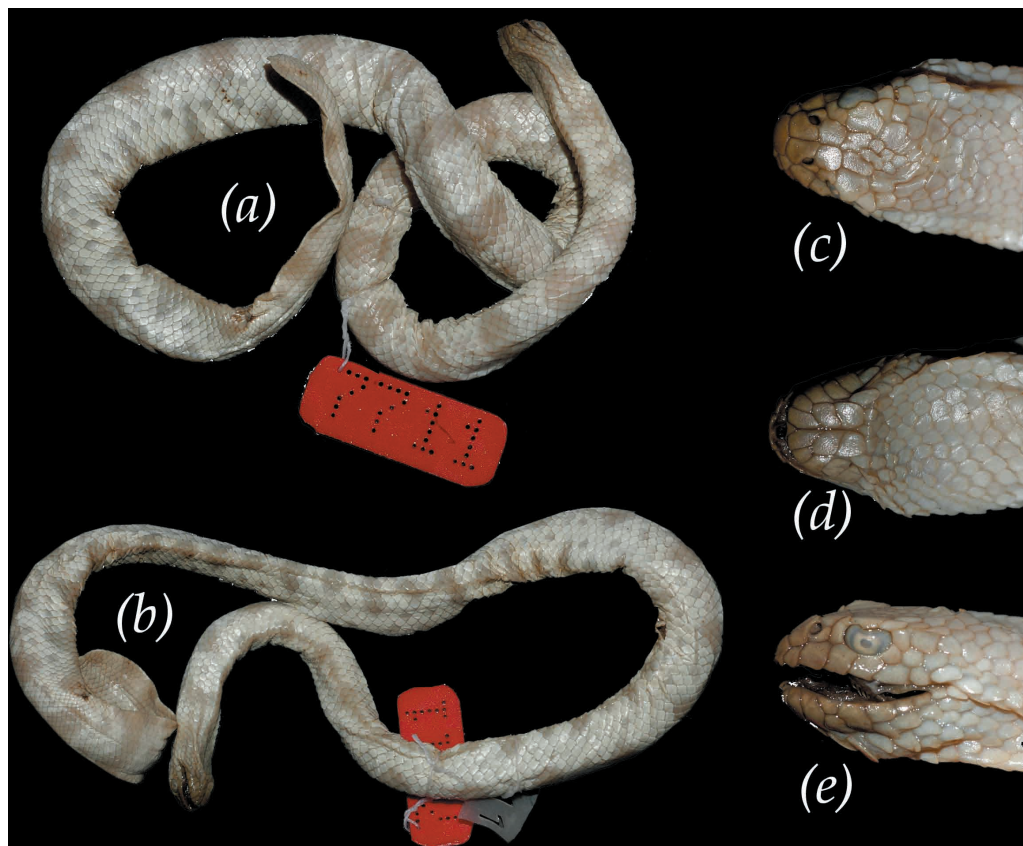


Fig. 28. *Acalyptophis peronii*, holotype of *Acalyptus peronii*, Australia, MNHN 7711. The dorsal (a) and ventral views (b). The dorsal (c), ventral (d) and lateral (e) views of head. Photo by I. Ineich.

Types. MNHN 7711 (holotype).

Diameter of eye greater than its distance from mouth. One or two preocular and three or four postoculars; six or seven supralabials; supralabials 3 and 4 in contact with eye; seven or eight infralabials. Scale rows 18–27 on neck, 23–32 on body; scales feebly imbricate and broader than long posteriorly. Scales with short keel, strong and spinous in adult males. Ventrals 142–222. Snout–vent length 1105 mm and tail length 165 mm (males) or snout–vent length 695 mm and tail length 50 mm.

Greyish or pale brown above, whitish below, with or without dark dorsal bars tapering to point on sides. Narrow ventral bands or spots may be present.

Distribution. South China, Taiwan, Thailand, Vietnam, Indonesia, Papua New Guinea, Australia, New Caledonia. A rare species in the waters of Vietnam.

References. Kharin (1984b, 2006); Rasmussen (2001); Rasmussen et al. (2011).

Genus *Thalassophis* P. Schmidt, 1852

Thalassophis P. Schmidt, 1852, p. 75 (type *Thalassophis anomala* P. Schmidt, 1852, by subsequent designation – Boulenger, 1896).

D i a g n o s i s. *Maxillare* extending forward beyond *palatinum* and much longer than *ectopterygoideum*. *Maxillare* with 5 teeth separated by diastema from fangs. *Palatinum* with 7 teeth, *pterygoideum* with 19–21 teeth, *dentale* with 17–19 teeth. Teeth on posterior limb of *dentale* with twisted tips that point inward and distinctly forward (unique in Elapoidea). *Palatinum* exceeding *maxillare* anteriorly, distinctly curved outward in frontal part, without facet for *maxillare*. *Palatinum*–*pterygoideum* articulation well posterior to *maxillare*–*praefrontale* articulation, but anterior to *maxillare*–*ectopterygoideum* articulation. *Basisphenoideum* excluded from anterior orifice of *cavum epiptericum* (BMNH 1927.9.28.26) or broadly entering ventral border of foramen (BMNH 1927.9.28.25 and 1930.5.8.807), with median keel. *Postorbitale* meeting *praefrontale*. *Parietale* also meeting *praefrontale* or narrowly excluded from this bone by *frontale*. *Quadratum* extending forward and backward. *Spleniale* with foramen. Frontal scute sometimes divided; prefrontal scute not dissected; nasal scute dissected into anterior and posterior scutes and into pair of internasals that separate remainders of nasal scutes on midline; rostral broken up into variable number of small scutes.

The genus is monotypic.

Thalassophis anomalus P. Schmidt, 1852

Fig. 29

Thalassophis anomala P. Schmidt, 1852, S. 81, taf. 4 (Semarang, Java, Indonesia).

T y p e s. ZMH R03342 (formerly 403, holotype).

Diameter of eye equal to its distance from mouth. One preocular and one or two postoculars; seven or eight supralabials; supralabials 3, 4, and 5 in contact with eye; eight or nine infralabials. Temporals small, not strongly differentiated from ordinary scales, 2+3 or 3+3. Scale rows 27–30 on neck, 31–35 on body. Posterior scales hexagonal in shape, as broad as or broader than long, juxtaposed and strongly keeled. Ventrals scarcely if any broader than adjacent dorsal scales, 210–256. Preanal scutes feebly enlarged. Snout–vent length 720 mm and tail length 90 mm (males) or snout–vent length 675 mm and tail length 85 mm.

Pale grey above, whitish below, with 30–36 dark dorsal bars, broader than interspaces and often connected vertebrally, tapering to point on sides or continued as narrow bands around body.

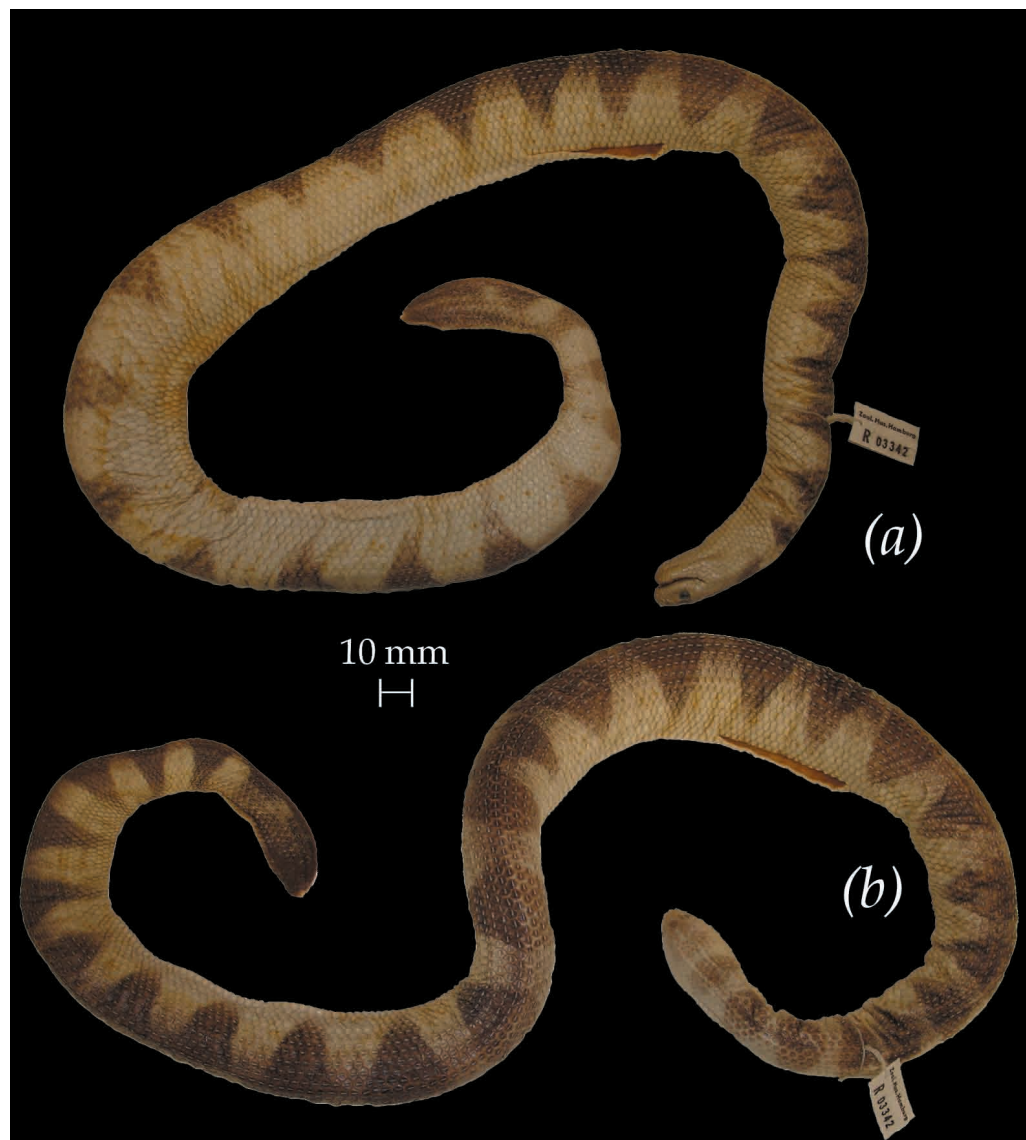


Fig. 29. *Thalassophis anomalus*, holotype of *Thalassophis anomala*, ZMH R03342, Semarang, Java. The dorsal (a) and ventral views (b). After Kharin, Hallermann (2009).

Distribution. Singapore, the Gulf of Thailand, Vietnam, East Sumatra, Borneo, and the Moluccas. A very rare species. Only a single specimen was found in the waters of Vietnam (Kharin, 2006).

References. McDowell (1972); Kharin (1984b, 2006); Rasmussen et al. (2011).

Genus *Pelamis* Daudin, 1803

Pelamis Daudin, 1803, p. 361 (type *Pelamis bicolor* Daudin, 1803 = *Anguis platura* Linnaeus, 1766, by subsequent designation – Gray, 1825).

Elaphrodites Gistel, 1848, p. ix (substitute name for *Pelamis*).

Pelamydrus Stejneger, 1910, p. 111 (substitute name for *Pelamis*).

D i a g n o s i s. *Maxillare* extending forward beyond *palatinum* and much longer than *ectopterygoideum*. *Maxillare* with 7–10 teeth separated by diastema from fangs. Teeth on *maxillare*, *dentale*, and median teeth on *palatinum* (beginning from 4th) separated by deep spaces. *Palatinum* with 6–7 teeth; *pterygoideum* with 23–28 teeth; *dentale* with 15–18 teeth. Articulation between *palatinum* and *pterygoideum* in front of *praefrontale*–*maxillare* and *pterygoideum*–*maxillare* articulations. *Spleniale* without foramen. *Angulare* equal to *spleniale*. *Praefrontale* and *postorbitale* not in contact with each other. *Frontale* entering orbit and excluding *parietale* from it. *Parietale* with sagittal crest. *Quadratum* long and narrow. *Basisphenoideum* broadly entering ventral margin of anterior orifice of *cavum epiptericum* and having median keel almost along its full length.

All scutes on head of regular symmetrical shape. Body covered with juxtaposed hexagonal or squarish scales. Ventrals absent in young, as well as in adult snakes.

The genus is monotypic.

Pelamis platura (Linnaeus, 1766)

Fig. 30

Anguis platura Linnaeus, 1766, p. 391 (origin unknown).

Hydrus bicolor Schneider, 1799 p. 242 (origin unknown).

Pelamis schneideri Rafinesque, 1817, p. 432 (substitute name for *Hydrus bicolor*).

Hydrophis pelamis Schlegel, 1837, p. 508, pl. xviii (substitute name for *Hydrus bicolor*).

Pelamis ornata Gray, 1842, p. 60 (Borneo = Kalimantan, Indonesia).

Pelamis bicolor var. *variegata* Duméril, Bibron, Duméril, 1854, p. 1337 (Macassar, Celebes = Sulawesi, Indonesia).

Pelamis bicolor var. *sinuata* Duméril, Bibron, Duméril, 1854, p. 1338 (origin unknown).

Hydrophis (*Pelamis*) *bicolor* var. *alternans* Fischer, 1856, S. 63 (substitute name for var. *variegata*).

Hydrophis bicolor var. *maculata* Jan in Jan, Sordelli, 1872, pl. iii, fig. 2 (Indian Ocean).

T y p e s unknown.

Head scutes having regular symmetrical form. Rostral with median fold anteriorly. This lobe fits into median notch in mental and completely divides lingual fossa of rostral into separate left and right grooves. One or two preoculars and two or three postoculars; seven or eight supralabials; supralabials 4 and 5 usually separated from eye; ten or eleven infralabials, without small cuneate scales interposed between them at oral margin. Number of scales on neck 41–42, at midbody 49–67. Body

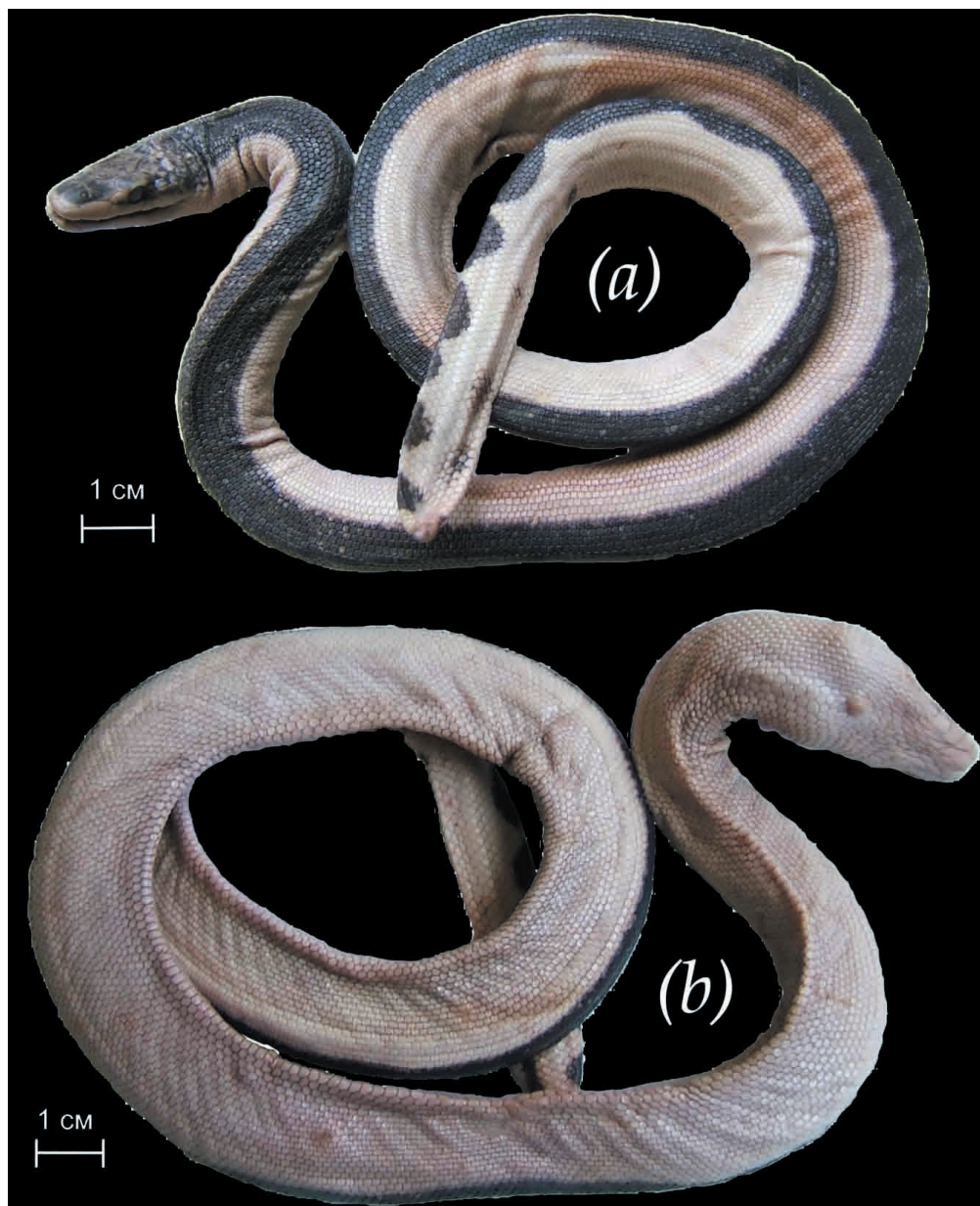


Fig. 30. *Pelamis platura* (ZISP 23585), Possjet Bay, Russia. The dorsal (a) and ventral views (b). After Kharin (2008).

scales with 2–3 tubercles. Number of ventrals 264–406, often divided by elongate groove. Snout–vent length: 640 mm in males and 790 mm in females; tail length: 80 mm in males and 90 mm in females.

Body coloration widely varies. M. Smith (1926) differentiated 7 types of coloration, but there are much more variations (Kharin, unpublished data). The most common type of coloration (including that of the South China Sea population) is considered a black dorsal side from the head to the beginning of the tail and a yellow or whitish ventral side of the head and the body. The tail is usually with longitudinally stretched black rhomboid or wedge-shaped patches, sometimes splitting into rounded spots.

Distribution. *P. platura* inhabits the marine pelagial and the seaward margins of the neritic zone in the Indian and Pacific oceans penetrating as far south as the Cape of Good Hope and New Zealand, and as far north as southern Japan and Peter the Great Bay. It is also distributed along the coasts of both Americas, from the Gulf of California to Chile. The Caribbean Sea. A common species in the waters of Vietnam.

References. Tirant (1885); Mocquard (1906); M. Smith (1926, 1943); Bourret (1934, 1936); Shuntov (1962, 1966); Pickwell (1972); Kharin (1984b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Dotsenko (1999, 2003); Rasmussen (2001); Nguyễn et al. (2005); Nguyễn et al. (2009); Rasmussen et al. (2011).

Genus *Hydrophis* Latreille in Sonnini et Latreille, 1801

Hydrophis Latreille in Sonnini, Latreille, 1801, p. 193 (type *Hydrophis laticauda* Latreille in Sonnini et Latreille, 1801 = *Hydrus fasciatus* Schneider, 1799, by monotypy).

Microcephalophis Lesson in Bélanger, 1834, p. 320 (type *Hydrus gracilis* Shaw, 1802, by monotypy).

Liopala Gray, 1842, p. 60 (type *Hydrus gracilis* Shaw, 1802, by monotypy).

Porrecticollis Wall, 1921, p. 335 (type *Hydrophis obscura* Daudin, 1803, by monotypy).

Micromastophis Wall, 1921, p. 344 (type *Aturia fasciata* (Schneider, 1799), by monotypy).

Mediohydrophis Kharin, 2004b, p. 450 (type *Hydrophis klossi* Boulenger, 1912, by original designation – Kharin, 2004b), pro subgenus.

Diagnosis. *Maxillare* extending forward beyond *palatinum* or not extending forward beyond *palatinum*. *Palatinum* much longer than *ectopterygoideum*. Tooth rows short to very short. *Maxillare* with 4–7 teeth separated by diastema from fangs, *palatinum* with 6–9 teeth, *pterygoideum* with 6–17 teeth, *dentale* with 11–16 teeth. Anterior part of *maxillare* arched upward, so that tip of fang nearly or quite in line with tips of solid *maxillare* teeth, although fang conspicuously longer than any of solid teeth; *palatinum* (except *H. macdowellii*) with triangular flange articulating with anterior medial process of *maxillare*. *Parietale* meeting *praefrontale* to exclude *frontale* from margin of orbit and from *postorbitale* or not quite meeting *praefrontale*, so that *frontale* enters margin of orbit and makes at least point-contact with *postorbitale*. *Quadratum* vertical, without backward inclination. *Spleniale* without foramen. *Basisphenoideum* entering broadly into margin of anterior orifice of *cavum epiptericum*.

Three subgenera with eleven species.

Subgenus *Microcephalophis* Lesson in Bélanger, 1834

D i a g n o s i s. *Maxillare* extending forward beyond *palatinum*. *Parietale* always connected with *praefrontale* separating *frontale* from orbital edge and from *postorbitale*. All posterior ventrals divided longitudinally (Fig. 8).

Two species.

Hydrophis gracilis (Shaw, 1802)

Fig. 31

Hydrus gracilis Shaw, 1802, p. 560 (origin unknown).

Hydrophis Kaddel-Nagam F. Boie, 1827 (India, based on Russell, pl. xiii).

Hydrophis leprogaster Duméril, Bibron in Fischer, 1856, p. 53 (*nomen nudum*).

Hydrophis guentheri Murray, 1884, p. 385 (Karachi, Pakistan).

Thalassophis microcephala P. Schmidt, 1852, S. 78, taf. ii (Java, Indonesia).

Hydrophis rostralis M. Smith, 1917, p. 340 (Kuala Larut, Perak, Malaysia).

T y p e s. 1946.1.17.37 (formerly III.4.1a, holotype).

Maxillare with 5–6 teeth separated by diastema from fangs. *Palatinum* with 7–8 teeth; *pterygoideum* with 9–12 teeth; *dentale* with 12–15 teeth. Diameter of eye equal to distance from eye to mouth corner. One preocular and one postocular; single anterior temporal; six supralabials; supralabials 3 and 4 in contact with eye; six or seven infralabials; no cuneate scales at oral margin between infralabials. Posterior scales hexagonal, juxtaposed, broader than long, with two or three very small tubercles, one behind another; lowermost rows of scales slightly larger than others and with very prominent tubercles or dentate keels in adults. From 17 to 23 scale rows on neck, 30 to 43 on body. Ventrals 215–350. Snout–vent length: 770 mm in males and 930 mm in females. Tail length: 80 mm in males and 95 mm in females.

Anterior part of body black, with whitish lateral patches (formed by dark bands merging dorsally) or complete pale transverse bands. Posterior part of body with more unbroken alternating black and whitish bands. Bands disappear with age and body becomes uniformly greyish.

D i s t r i b u t i o n. From Arabian Gulf to the South China Sea and Indonesia, the Arafura Sea to the Gulf of Papua. Kharin (2004b) defined two subspecies with *H. g. microcephalus* (Fig. 32) occurring in the middle of the range of the typical form (Natuna and Java Seas). A common species in the waters of Vietnam.

R e f e r e n c e s. Mocquard (1906); M. Smith (1926, 1943); Bourret (1934, 1936); Shuntov (1962); Bùi Văn Du'ong (1978); Tran, Nguyễn (1980); Kharin (1984b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Dotsenko (1999, 2003); Nguyễn et al. (2005); Rasmussen et al. (2007); Nguyễn et al. (2009); Rasmussen et al. (2011).

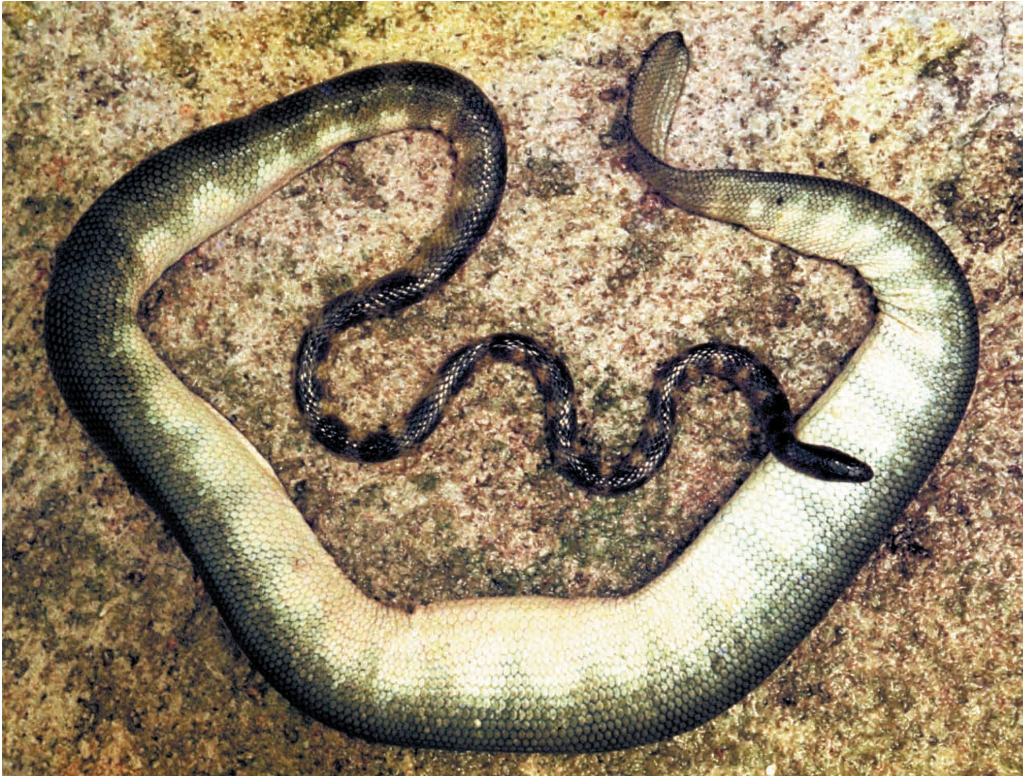


Fig. 31. *Hydrophis gracilis* (FMNH 201935), Mersing, Malaysia.

Subgenus *Mediohydrophis* Kharin, 2004

Diagnosis. *Maxillare* not extending forward beyond *palatinum*. *Parietale* always connected with *praefrontale*, making *frontale* separated from orbital edge and from *postorbitale*. Most of posterior ventrals not divided.

Hydrophis klossi Boulenger, 1912

Fig. 33

Hydrophis klossi Boulenger, 1912, p. 190 (Selangor, Malaysia).

Types. BNNH 1946.1.10.8 (formerly 1920.6.3.7, holotype).

Maxillare with 5–6 teeth separated by diastema from fangs. *Palatinum* with 6–7 teeth; *pterygoideum* with 7–10 teeth; *dentale* with 12–13 teeth. Diameter of eye equal to or slightly less than its distance from mouth. One preocular and one postocular; one large anterior temporal; five or six supralabials; supralabials 3 and 4 in contact with eye; six or seven infralabials. Scales imbricate throughout and

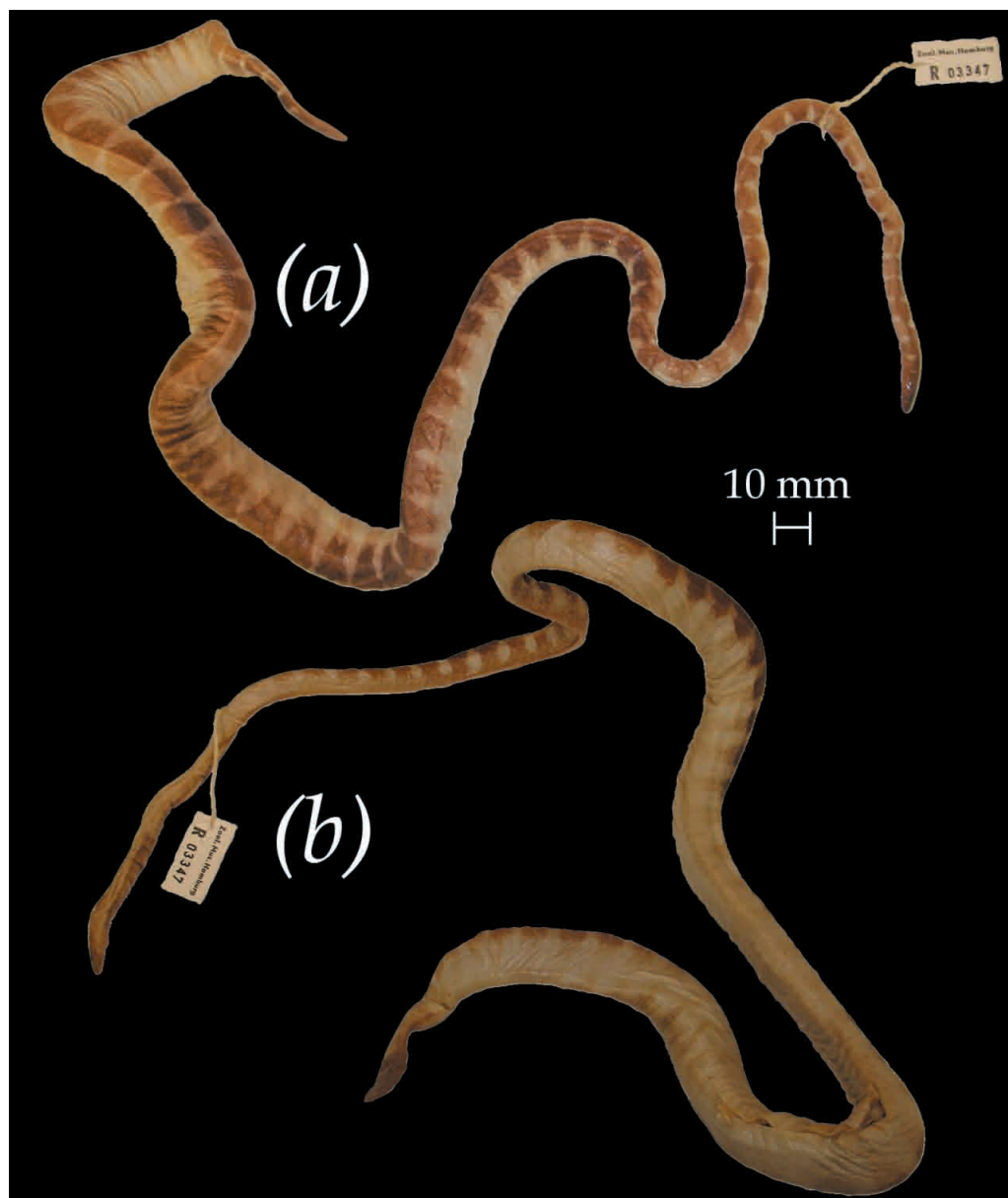


Fig. 32. *Hydrophis gracilis melanocephalus*, syntype of *Thalassophis microcephalus*, ZMH R03347. The dorsal (a) and ventral views (b). After Kharin, Hallermann (2009).

smooth or feebly keeled. From 23 to 27 scale rows on neck, 31 to 39 on body. Ventrals 360–413. Snout–vent length 975 mm in males and 1190 mm in females. Tail length: 115 mm in males and 110 mm in females.



Fig. 33. *Hydrophis klossi* (TINRO R 036), South Vietnam.

Body grayish yellow with 50–75 dark or black bands, dorsally broader than their interspaces. Head greyish black, sometimes with indistinct pale horseshoe-shaped mark above.

Distribution. The Strait of Malacca, the Gulf of Thailand, Cambodia, southern Vietnam and Indonesia (Sumatra). A very rare species in the waters of southern Vietnam (TINRO R 036, two specimens).

References. Kharin (1984b, 2006); Rasmussen et al. (2007, 2011).

Subgenus *Hydrophis* Latreille in Sonnini et Latreille, 1801

Diagnosis. *Maxillare* not extending forward beyond *palatinum*. *Parietale* connected with *praefrontale* incompletely so that *frontale* partially enters into orbital margin and contacts with *postorbitale*. Most of posterior ventrals not divided.

***Hydrophii brookii* Günther, 1872**

Fig. 34

Hydrophii brookii Günther, 1872b, p. 597, fig. (Sarawak, Malaysia).

Hydrophis consobrinus M. Smith, 1917, p. 341 (Gulf of Thailand).

Type s. BMNH 1946.1.1.57 (formerly 72.2.16.58, holotype).

Maxillare with 5 teeth separated by diastema from fangs. *Palatinum* with 7–8 teeth; *pterygoideum* with 14–15 teeth; *dentale* with 15–16 teeth. Diameter of eye equal to or greater than its distance from mouth. One preocular or one and two postoculars; single large anterior temporal; five or six supralabials; supralabials 3 and 4 in contact with eye; five or six infralabials; cuneate scale usually present at oral margin between infralabials 3 and 4. Posterior scales subimbricate and more or less hexagonal in shape, with central tubercle or short keel. From 25 to 31 scale rows on neck, 37 to 45 on body. Ventrals 328–414. Snout–vent length: 920 mm in males and 890 mm in females. Tail length: 115 mm in males and 75 mm in females.

Body bluish white, with 60 to 80 dark or black bands. Bands completely encircle body anteriorly, but posteriorly they taper on sides and may be incomplete below. Head blackish, with yellow horseshoe mark on upper side.

Distribution. The Indo-Malayan Archipelago, the South China Sea and the northern coasts of Kalimantan and Java. A common species in the waters of southern Vietnam.

References. M. Smith (1926, 1943); Bourret (1934, 1936); Bùi Văn Du'ng (1978); Tran, Nguyễn (1980); Kharin (1984b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Dotsenko (1999, 2003); Nguyễn et al. (2005); Rasmussen et al. (2007); Nguyễn et al. (2009); Rasmussen et al. (2011).

***Hydrophis atriceps* Günther, 1864**

Figs. 35, 36

Hydrophis atriceps Günther, 1864, p. 371, pl. xxv, fig. 1 (Siam = Thailand).

Hydrophis cinnammati Van Derburgh, Thompson, 1908, p. 41, pl. (NE of Cavite, Manila Bay, Philippines).

Type s. BMNH 1946.1.2.62 (formerly 62.11.1.255) and 63.9.29.5 (two syntypes).

Maxillare with 5–6 teeth separated by diastema from fangs. *Palatinum* with 7–8 teeth; *pterygoideum* with 8–13 teeth; *dentale* with 13–15 teeth. Diameter of eye equal to or greater than its distance from mouth. One preocular and one or two postoculars; six, seven, rarely five supralabials, supralabials 3 and 4 in contact with eye; single anterior temporal; seven or eight infralabials; small cuneate scale usually present at margin between infralabials 3 and 4. Posterior scales subimbricate and

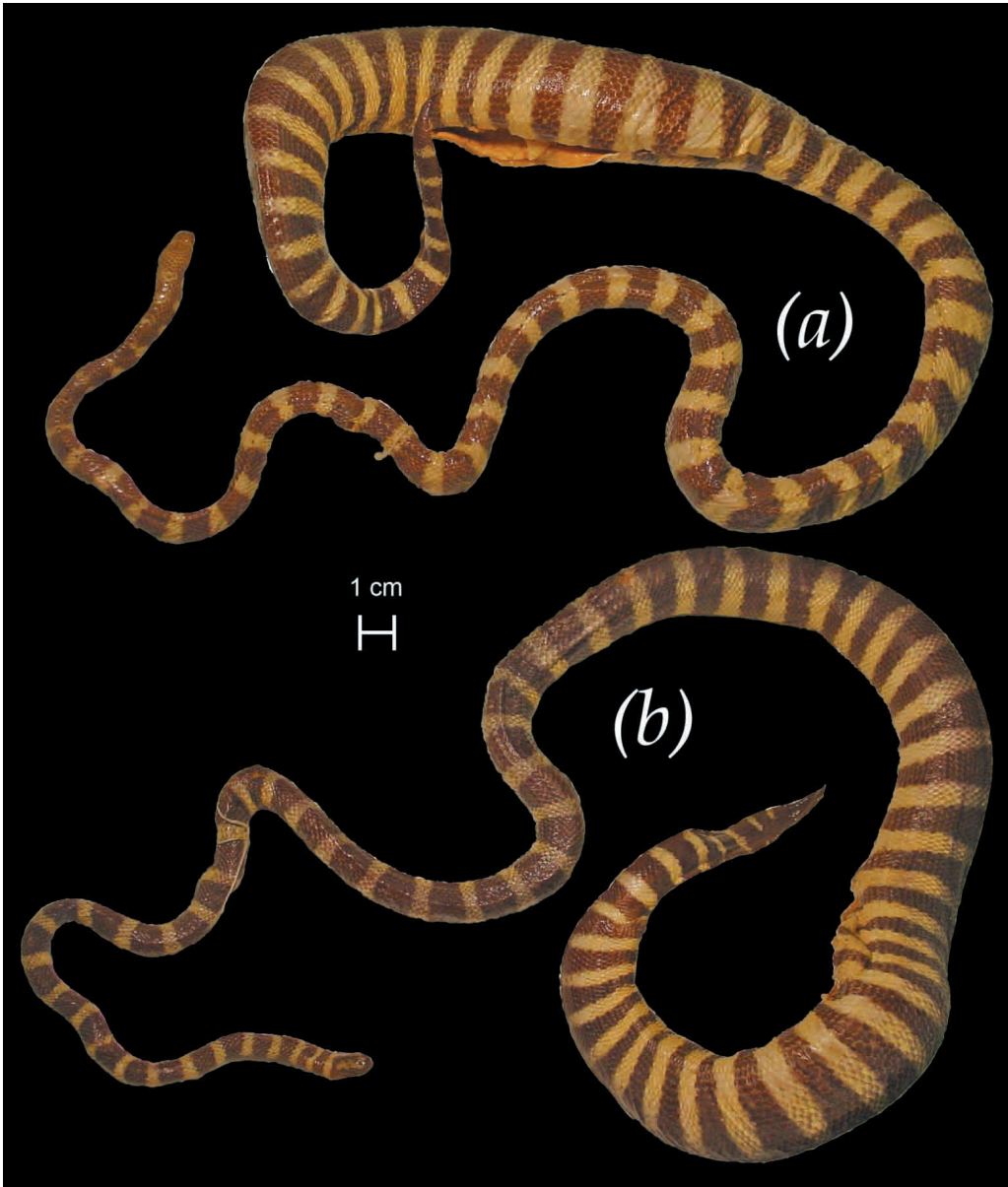


Fig. 34. *Hydrophis brookii*, holotype, BMNH 1946.1.1.57, Sarawak, Malaysia. Photo by C.J. McCarthy.

more or less hexagonal in shape, with central tubercle or keel. From 25 to 30 scale rows on neck, 39 to 49 on body. Ventrals 320–455. Snout–vent length: 1010 mm in males and 915 mm in females. Tail length: 100 mm in males and 75 mm in females.



Fig. 35. *Hydrophis atriceps* (FMNH 198841), Parit Botak, Malaysia. Photo by H.K. Voris.

Anterior part of body dark or black with pale yellowish oval spots on sides or spots merging into bands. Posterior part of body greyish white above, whitish below, with 50–75 dark bands that may extend down sides to form complete bands. Head dark or black.

Distribution. The Gulf of Thailand, Singapore, the South China Sea, the Philippines, Indonesia (Java) and the Arafura Sea. A common species of the waters of Vietnam.

References. Mocquard (1906); M. Smith (1926, 1943); Bourret (1934, 1936); Shuntov (1962); Pickwell (1972); Bùi Văn Du'ng (1978); Tran, Nguyễn (1980); Kharin (1984b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Rasmussen (2001); Rasmussen et al. (2007); Nguyễn et al. (2009); Rasmussen et al. (2011).

Hydrophis parviceps M. Smith, 193

Fig. 37

Hydrophis parviceps M. Smith, 1935, p. 2, fig. (coast of South Vietnam).

Types. ZMUC R66182.

Maxillare with 6–7 teeth separated by diastema from fangs. *Palatinum* with 7 teeth; *pterygoideum* with 10 teeth; *dentale* with 14 teeth. Diameter of eye equal to or greater than its distance from mouth. One preocular and one postocular; six or

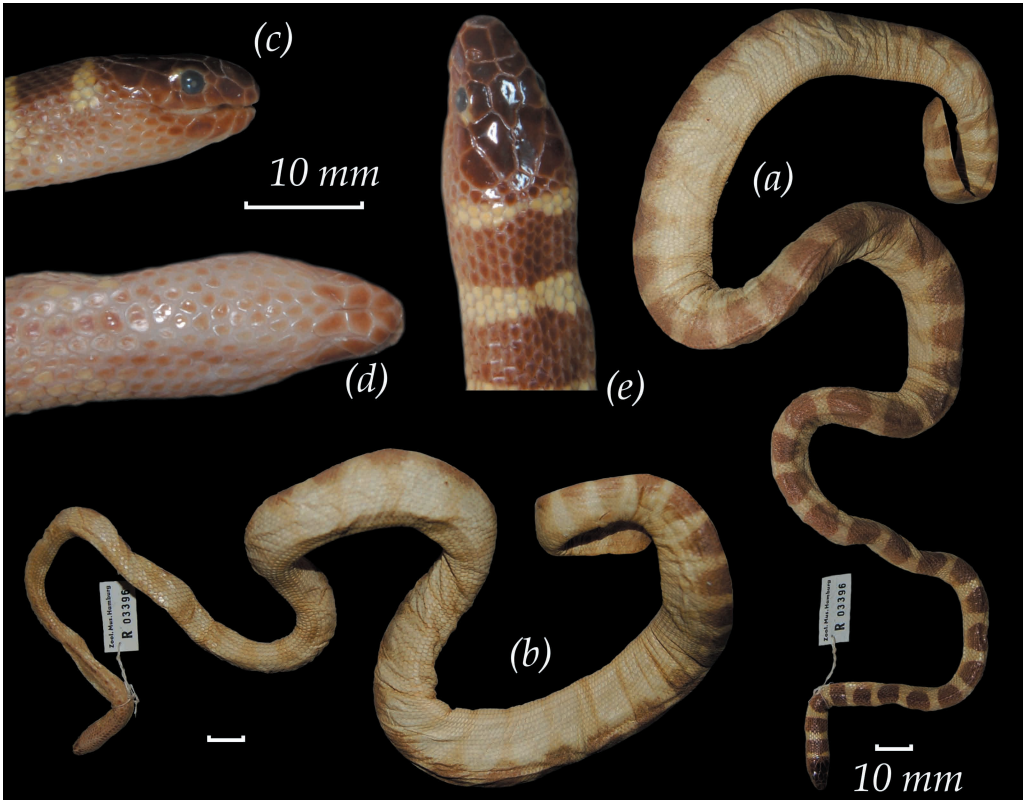


Fig. 36. *Hydrophis atriceps* (ZMH R3396), Thailand. Photo by J. Hallermann.

seven supralabials; supralabials 3 and 4 in contact with eye; six, seven or eight infralabials. No small cuneate scale at oral margin between infralabials. Scales smooth on anterior quarter of body, keeled from approximately a quarter of body length with keels increasing in length and height posteriorly, where keel length nearly equals that of scales. From 19 to 21 scale rows on neck, 31 to 34 on body. Ventrals 329–348. Snout–vent length: 1000 mm in males and 1120 mm in females. Tail length: 130 mm in males and 110 mm in females.

Body olivaceous above, greyish below, with 65–70 blackish bands. Head black with no or only several faint paler marks. Head black above and below.

Distribution. Vietnam. A very rare species. Only six specimens in the waters of southern Vietnam (Rasmussen et al., 2011). One record in northern Vietnam (TINRO R 47, Tonkin Bay, our data).

References. M. Smith (1935, 1943); Taylor (1963); Kharin (1984b, 2006); Nguyễn, Hó (1996); Nguyễn et al. (2005); Rasmussen et al. (2007); Nguyễn et al. (2009); Rasmussen et al. (2011).

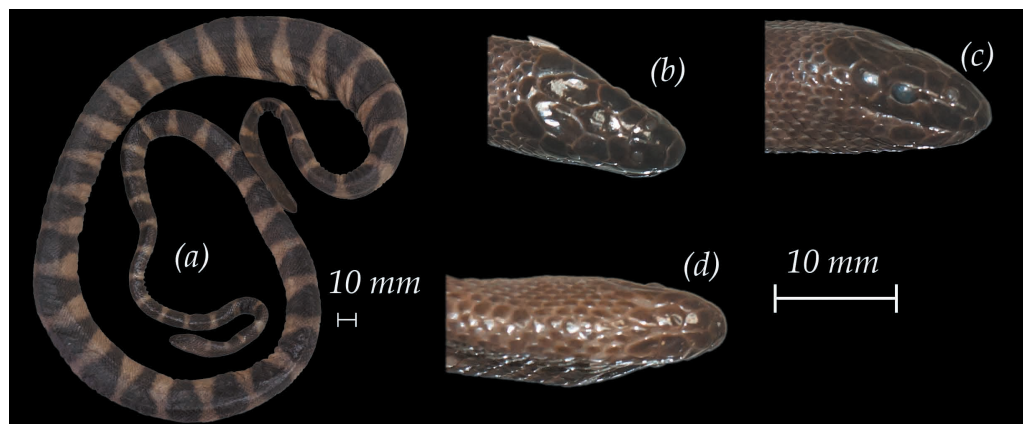


Fig. 37. *Hydrophis parviceps* (TINRO R 047), Gulf of Tonkin.

Genus *Leioselasma* Lacépède, 1804

Leioselasma Lacépède, 1804, p. 210 (type: *Leioselasma striata* Lacépède, 1804 = *Hydrophis cyanocinctus* Daudin, 1803, by monotypy).

D i a g n o s i s. *Maxillare* longer than *ectopterygoideum*, without posterior process, not extending forward beyond *palatinum*; anterior part of it not arcuate, and tip of fang projecting conspicuously below line connecting tips of *maxillare* teeth. *Palatinum* without triangular flange for *maxillare*, but with tubercle-like convexity. *Maxillare* with 5–8 teeth separated by diastema from fangs. *Palatinum* with 5–9 teeth. *pterygoideum* with 7–18 teeth; *dentale* with 15–18 teeth. Tooth rows of moderate length. *Quadratum* extended downward and backward. *Frontale* excluded from orbit border. *Parietale* with sagittal crest; *parietale* articulated with *praefrontale*, excluding *frontale* from border of orbit and from contact with *postorbitale*. *Spleniale* without foramen. *Basisphenoideum* with median keel, nearly or utterly excluded from ventral margin of anterior orifice of *cavum epiptericum*.

The genus comprises eight species.

Leioselasma spiralis (Shaw, 1802)

Figs. 38–40

- Hydrus spiralis* Shaw, 1802, p. 564, pl. 126 (Indian Ocean).
- Hydrophis brugmansi* F. Boie, 1827, S. 554 (Indian Ocean).
- Hydrophis melanurus* Wagler, 1828, pl. iii (Western Indian Ocean).
- Hydrophis sublaevis* Gray, 1842, p. 62 (part., only Madras, India).
- Hydrophis robusta* Günther, 1864, p. 364 (origin unknown).
- Hydrophis rappii* Jan in Jan, Sordelli, 1872, pl. iv (origin unknown).
- Hydrophis temporalis* Blandford, 1881, p. 680, fig. (Gangestum, Iran).
- Hydrophis bishopii* Murray, 1884, p. 391, pl. (Karachi, Pakistan).
- Hydrophis melanocinctus* Wall, 1906, p. 287 (Puri, Orissa, India).

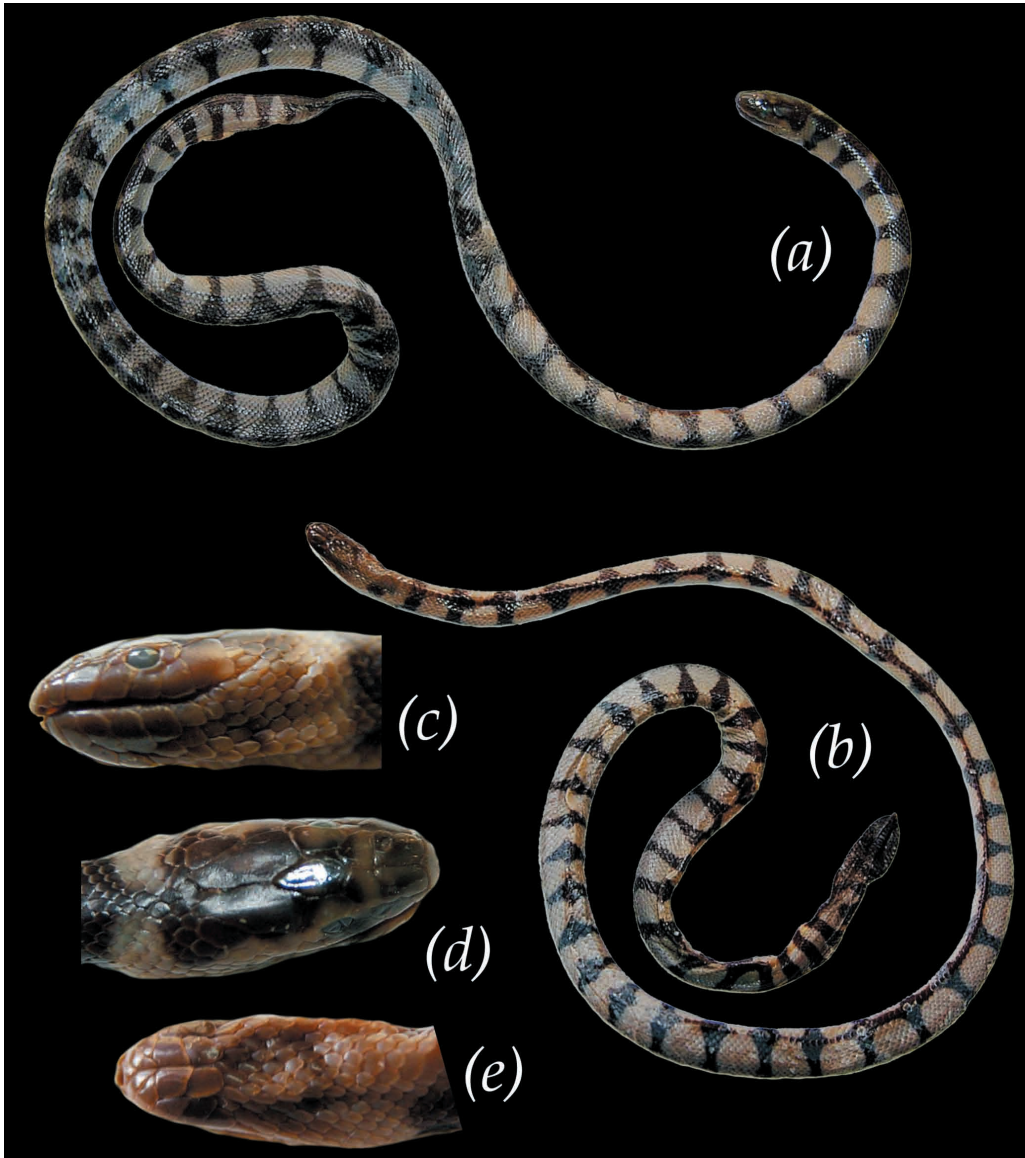


Fig. 38. *Leioselasma spiralis* (ZMNMNH 1922/4712), South Vietnam. The dorsal (a) and ventral views (b); the lateral (c), dorsal (d) and ventral (e) views of the head. Photos by I.B. Dotsenko and V.I. Radchenko.

Type s. BMNH 1946.1.6.94 (formerly III.6.10.c, holotype).

Maxillare with 6–7 teeth separated by diastema from fangs. *Palatinum* with 6–7 teeth; *pterygoideum* with 12–14 teeth; *dentale* with 14–16 teeth. Diameter of eye in adults less than distance between eye and mouth corner. One preocular and one or



Fig. 39. *Leioselasma spiralis* (FMNH 201042), Muar, Malaysia. Photo by H.K. Voris.

two postoculars; single large anterior temporal; supralabials six to eight; supralabials 3, 4, and 5, or only two of them, in contact with eye; seven to ten infralabials; usually cuneate scale at oral margin after infralabials 3 or 4. Body scales feebly imbricate throughout, smooth or with a small central tubercle or short keel. From 25 to 31 scales on neck, from 33 to 38 scales at midbody. Ventrals 295–362. Snout–vent length: 1480 mm in males and 1710 mm in females. Tail length: 140 mm in males and 120 mm in females.

Yellowish or yellowish-green, dorsal scales with black margins and with more or less complete narrow black annuli much narrower than their interspaces, and usually dilated vertebrally. Dorsal spots often present on bands; black ventral line may be present in young specimens. Head in adults usually entirely yellow.

Distribution. Persian Gulf, India, Sri Lanka, Myanmar, the west coast of Thailand, Malaysia, the Gulf of Thailand, Vietnam, the Philippines, Indonesia (Sumatra, Java and Kalimantan), and New Caledonia. Only a single record in the waters of Vietnam (ZMNMNH 1922/4712).

References. Dotsenko (1999, 2003); Rasmussen et al. (2011).

Leioselasma cyanocincta (Daudin, 1803)

Figs. 41–43

Hydrophis cyanocinctus Daudin, 1803, p. 383 (Sunderbunds, India, based on Russell pl. ix).

Leioselasma striata Lacépède, 1804, p. 210, pl. lvii, fig 1. (New Holland = Australia).

Hydrophis chittul Rafinesque, 1817, p. 432 (substitute name for *Hydrophis cyanocinctus*).

Hydrophis subannulata Gray, 1849, p. 54 (India).

Hydrophis aspera Gray, 1849, p. 54 (Singapore).

Hydrophis westermanni Jan, 1859, p. 151 (Manila Bay, Philippine).



Fig. 40. *Leioselasma spiralis*, Vadodara, Gujarat, India. Photo by V.V. Rajendra.

Hydrophis trachyceps Theobald, 1868, p. 70 (Mergui Archipelago).
Hydrophis crasicollis Anderson, 1871a, p. 19 (Calcutta, India).
Hydrophis tuberculata Anderson, 1871a, p. 18 (Calcutta, India).
Hydrophis dayanus Stoliczka, 1872, p. 89 (Karachi, Pakistan).
Hydrophis tenuicollis W. Peters, 1872, p. 854, taf. 2, fig. 1 (Java, Indonesia).
Hydrophis taprobanica Haly, 1887, p. 107 (Ceylon Island = Sri Lanka).
Hydrophis phipsoni Murray, 1887, p. 32, pl. (Bombay, India).
Distira saravacensis Boulenger, 1900, p. 184, pl. xiv fig. 2 (Sarawak river, Sarawak Island).
Distira longissima Rosen, 1905, p. 178 (origin unknown).

Type s. BMNH 1946.1.9.23 (formerly III.3.25.6, holotype).

Maxillare with 5–9 teeth separated by diastema from fangs. *Palatinum* with 5–9 teeth; *pterygoideum* with 14–18 teeth; *dentale* with 15–18 teeth. Diameter of eye in adults less than distance between eye and mouth corner. One preocular and two postoculars; two superposed anterior temporals; seven or eight supralabials; supralabials 3, 4, and 5, or only two them in contact with eye; eight to ten infralabials; series of small scales at oral margin after infralabial 2 or 3. Body scales with bidentate keels. From 25 to 35 scales on neck; from 37 to 47 scales on midbody. Ventrals 253–334. Snout–vent length: 1370 mm in males and 1750 mm in females. Tail length: 130 mm in males and 135 mm in females.

Body coloration widely varies. M. Smith (1926) differentiated five types of coloration. First three types are based on the shapes of cross bands that may be complete or incomplete, well expressed on the back and upper lateral sides and poorly expressed ventrally, and so on. Two other types of coloration differ in the arrangement of spots: spots only on the lateral sides, or spots only on the dorsal side excluding the neck and the head. A yellow mark on the head may be present or not. The cross bands and the spots are more distinct in the anterior part of the body, becoming blurred in its posterior part and on the tail.

Distribution. Persian Gulf, Pakistan, India, Sri Lanka, Thailand, Myanmar, Malaysia, Indonesia (Kalimantan, Java, Sumatra), Vietnam, the Philippines, China, Taiwan, and southern Japan.

References. Mocquard (1906); M. Smith (1926, 1943); Bourret (1934, 1936); Shuntov (1962, 1966); Pickwell (1972); Bùì Văn Du'ông (1978); Tran, Nguyễn (1980); Kharin (1984a, b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Dotsenko (1999, 2003); Nguyễn et al. (2005); Rasmussen et al. (2007); Nguyễn et al. (2009); Rasmussen et al. (2011).

Leioselasma melanocephala (Gray, 1849)

Fig. 44

Hydrophis sublaevis var. *melanocephala* Gray, 1849, p. 53 (?Indian Ocean, part.).
Disteira orientalis Stejneger, 1901, p. 191 (Okinawa Shima, Riukiu Islands, Japan).



Fig. 41. *Leioselasma cyanocincta*, holotype of *Hydrophis cyanocinctus*, BMNH 1946.1.9.23, Sunderbunds, India. The dorsal (a) and ventral views (b). Photo by C.J. McCarthy.

Types. BMNH 1946.1.9.22 (formerly 47.3.4.68, holotype).

Maxillare with 6–8 teeth separated by diastema from fangs. *Palatinum* with 7–9 teeth; *pterygoideum* with 14–17 teeth; *dentale* with 16–18 teeth. Diameter of eye equal to or more than distance from eye to mouth corner. One preocular and one or two postoculars, normally single large anterior temporal; seven or eight supralabials;



Fig. 42. *Leioselasma cyanocincta* (FMNH 198904), Parit Botak, Malaysia. Photo by H.K. Voris.

seven or eight infralabials; series of small scales at oral margin after infralabials 2 or 3. Body scales usually with keels. From 23 to 27 scales on neck, from 33 to 41 scales on midbody. Ventrals 289–358. Snout–vent length: 1035 mm in males and 1140 mm in females. Tail length: 95 mm in males and 90 mm in females.

Body olive or greyish above, yellowish or whitish below, with 40–55 black or dark brown cross bands. Cross bands broader than yellowish or greyish spaces between them on dorsal side and narrower than these spaces on lateral sides; bands more distinct on posterior part of body and on tail. Head black or dark brown with yellow spot behind each nostril and with yellow streak behind each eye.

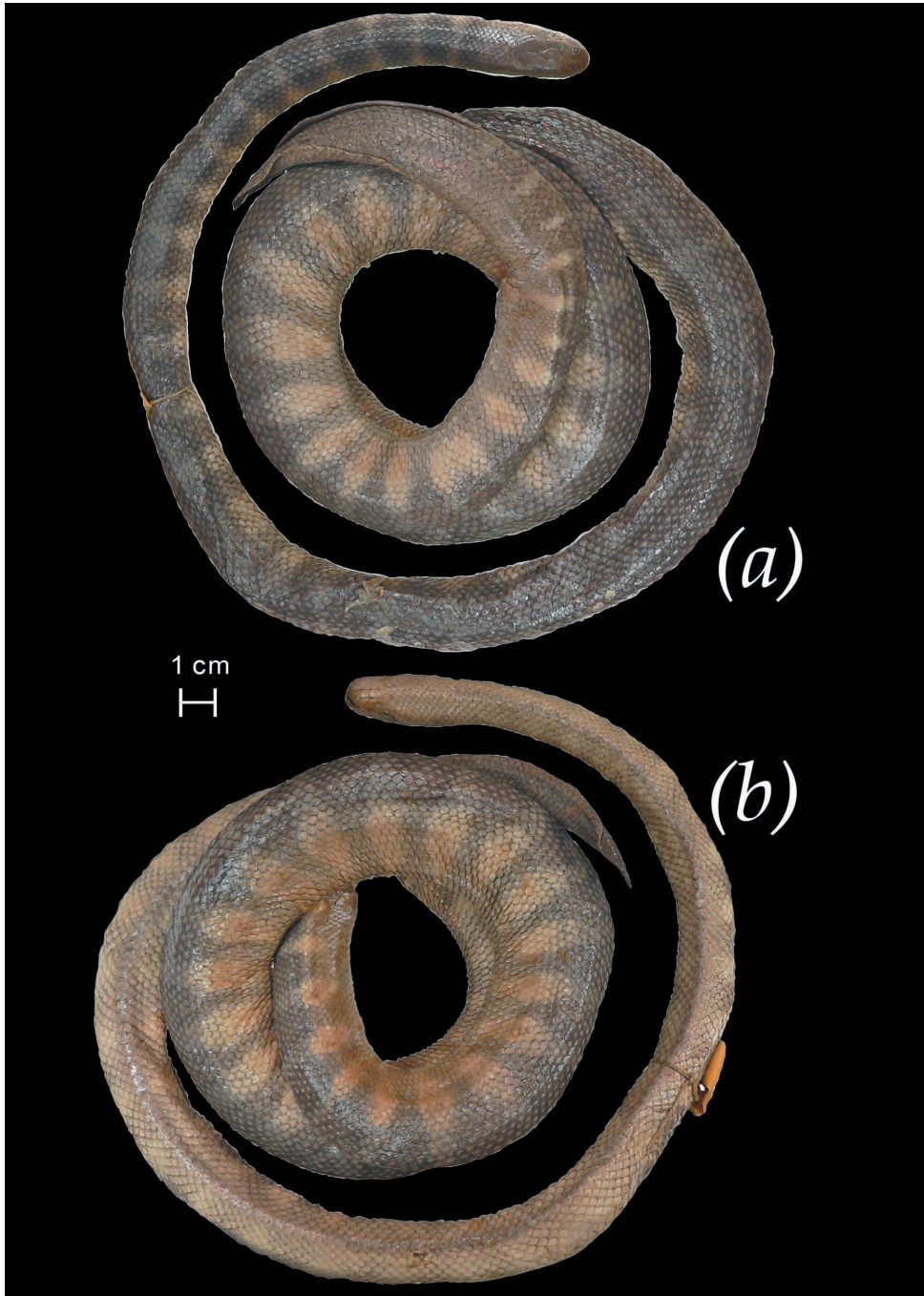


Fig. 43. *Leioselasma cyanocincta* (TINRO R 039), South China Sea. The dorsal (a) and ventral views (b). After Kharin, Czeblukov (2008).

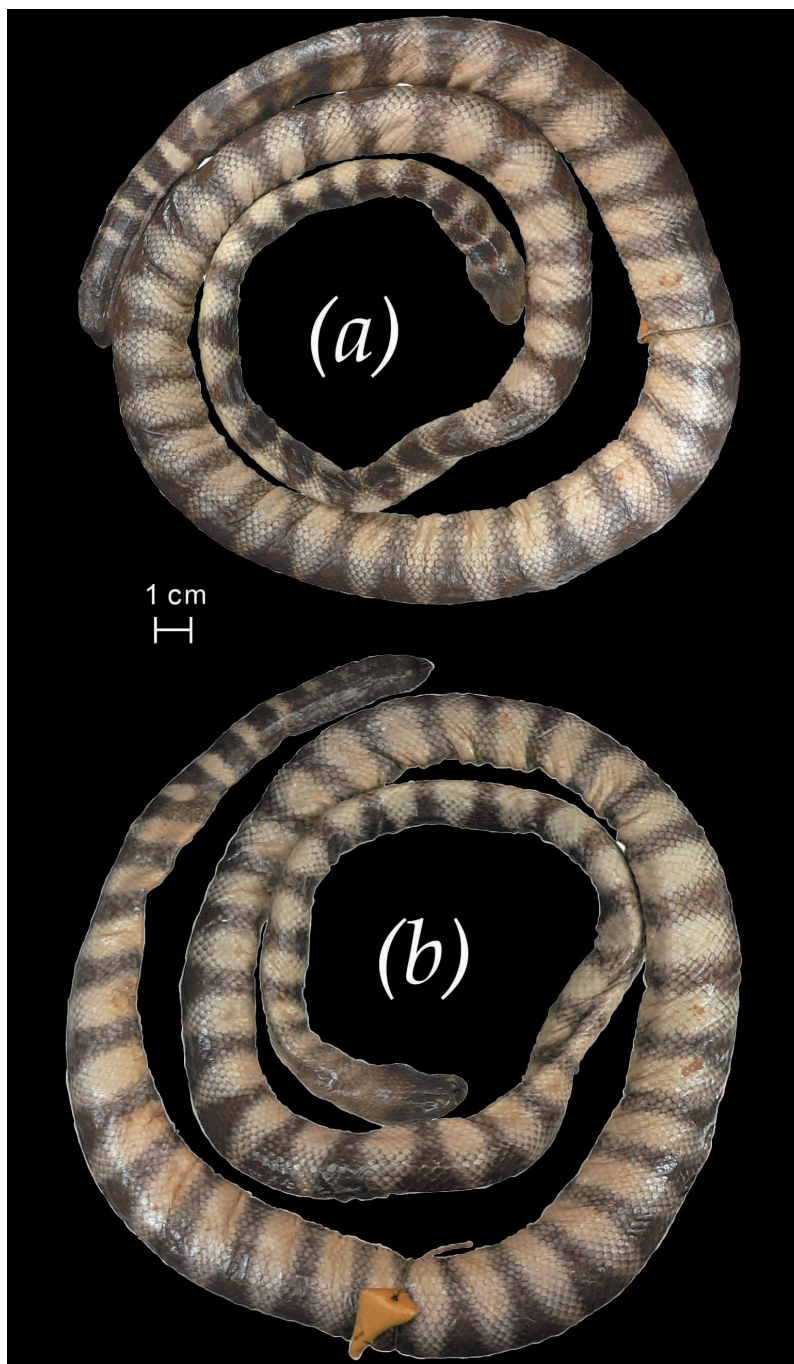


Fig. 44. *Leioselasma melanocephala* (TINRO R 044), South China Sea. The dorsal (a) and ventral views (b). After Kharin, Czeblukov (2008).

Distribution. The coastal waters of southern Japan (Honshu and Ryukyu islands), the Philippines, the South China Sea (Hainan Island), and Vietnam. A common species in the waters of North Vietnam.

References. Kharin (1984a, 2006); Nguyễn et al. (2009); Rasmussen et al. (2011).

Genus *Chitulia* Gray, 1849

Aturia Gray, 1842, p. 61 (type *Aturia ornata* Gray, 1842, by subsequent designation – M. Smith, 1926), *nomen praeoccupatum* (non Bronn, 1838, Mollusca).

Chitulia Gray, 1849, p. 56 (type *Chitulia inornata* Gray, 1849, by subsequent designation – M. Smith, 1926).

Dolichodira Wall, 1921, p. 339 (type *Hydrophis diadema* (non Günther, 1864) = *Hydrophis stricticollis* Günther, 1864), by monotypy).

Polypholophis Wall, 1921, p. 380 (type *Hydrophis neglectus* Wall, 1906 = *Hydrophis stricticollis* Günther, 1864, by monotypy).

Diagnosis. *Maxillare* longer than *ectopterygoideum*, without posterior process, and not extending forward beyond *palatinum*; its anterior part not arcuate, and tip of fang projecting conspicuously below line connecting tips of maxillary teeth. *Palatinum* without triangular flange for *maxillare*, often with tubercle-like convexity. *Maxillare* with 6–18 teeth separated by diastema from fangs. *Palatinum* with 6–10 teeth; *pterygoideum* with 18–27 teeth; *dentale* with 17–23 teeth. Tooth rows moderate to long. *Quadratum* with slight backward inclination (in most species) or with strong inclination (*C. ornata*, *C. inornata*). *Frontale* excluded from orbit border. *Parietale* with sagittal crest and articulated with postorbital excluding *frontale* from border of orbit. *Angulare* equal to *spleniale*. *Spleniale* without foramen. *Basisphenoidium* with median keel and broadly enters ventral margin of anterior orifice of *cavum epiptericum*.

The genus comprises eleven species.

Chitulia torquata diadema (Günther, 1864)

Figs. 45, 46

Hydrophis diadema Günther, 1864, p. 373, pl. xxv, fig. S (origin unknown).

Hydrophis siamensis M. Smith, 1917, p. 341 (Bight of Bangkok, Thailand).

Types. BMNH 1946.1.7.5-6 (formerly 55.10.16.301, two syntypes).

Maxillare with 8–10 teeth separated by diastema from fangs. *Palatinum* with 6–8 teeth; *pterygoideum* with 18–22 teeth; *dentale* with 16–19 teeth. Normally two supralabials (third and fourth) bordering eye. Diameter of eye equal to distance from eye to mouth corner. Single anterior temporal; seven or eight supralabials; eight or nine infralabials; one preocular and one or two postoculars. Posterior scales

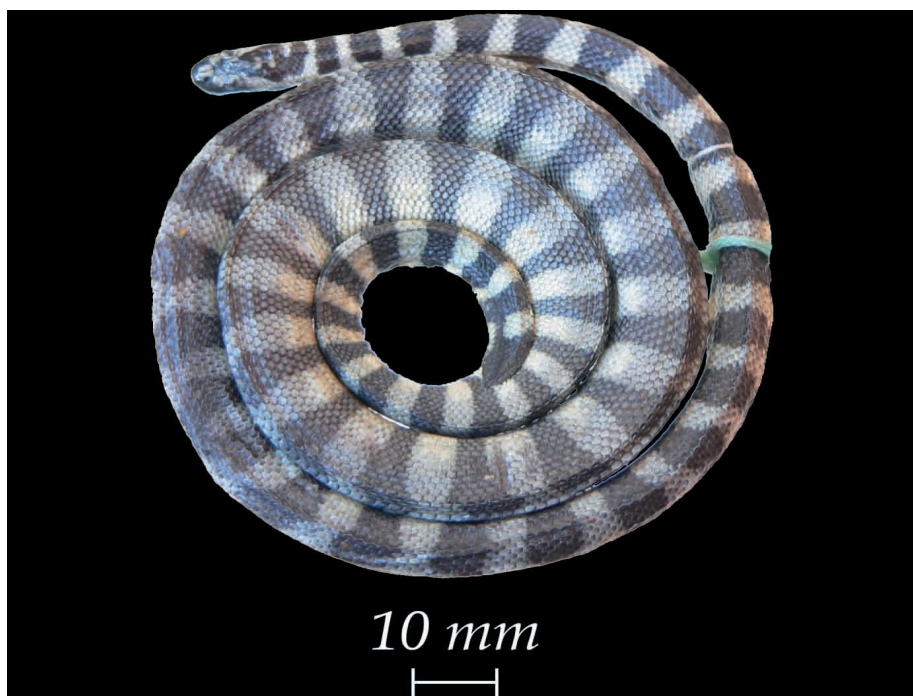
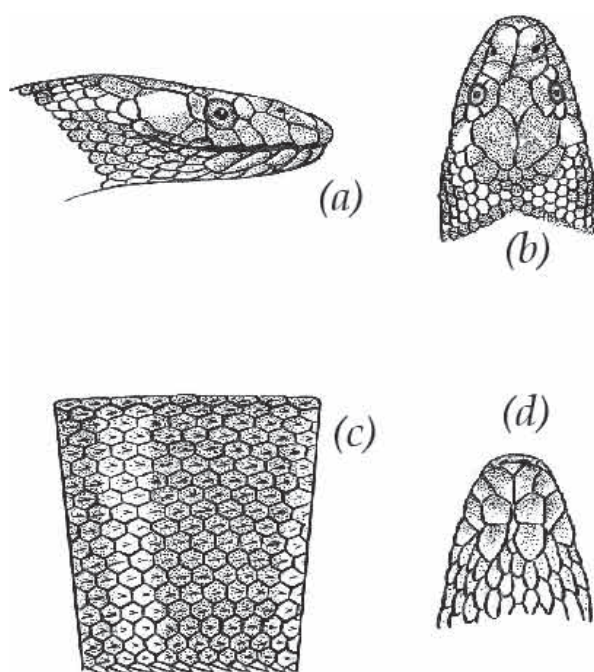


Fig. 45. *Chitulia torquata diadema* (MIMB, not catalogued,), Vung Tau, South Vietnam.



more or less hexagonal in shape, subimbricate, and with central tubercle or short keel. Number of scales on neck 29–31, number of scales on midbody 35–42. Ventrals 286–320. Snout-vent length 770 mm in males and 940 mm in females. Tail length 115 mm in males and 105 mm in females.

Body grey or whitish above, yellow or whitish below, with black bands, often incomplete

Fig. 46. *Chitulia torquata diadema* (MNHN 63-7443), Cambodia. The lateral (a), dorsal (b) and ventral (d) views of the head; scales of the mid-body (c).

below. Bands fade and disappear with age, leaving back more or less uniform grey. Head black with one yellowish band across snout and one along sides.

Distribution. Eastern Thailand, Cambodia, southern Vietnam, South China. Very rare species in the waters of Vietnam. Only single specimen found in the waters of Vietnam (MIMB, not catalogized, Vietnam, Vung Tau).

Remarks. *Ch. torquata diadema* is easily discernible by its coloration pattern and peculiarities of the pholidosis. It apparently is a distinct species (Kharin, Czeb-lukov, 2007; Kharin, Dotsenko, 2012).

References. M. Smith (1926, 1943); Bourret (1934); Ineich (1996); Nguyễn, Hó (1996); Nguyễn et al. (2005); Nguyễn et al. (2009); Rasmussen et al. (2011).

***Cbitulia belcheri* (Gray, 1842)**

Figs. 47, 48

Aturia belcheri Gray, 1849, p. 46 (New Guinea).

Types. BMNH 1946.1.97 (formerly III.3.2a, holotype).

Maxillare with 6–9 teeth separated by diastema from fangs. *Palatinum* with 7–9 teeth; *pterygoideum* with 15–17 teeth; *dentale* with 17–19 teeth. Normally only one supralabial (fourth) bordering eye, but rarely two (third and fourth, or fourth and fifth). Diameter of eye equal to distance from eye to mouth corner. One preocular and one or two postoculars; two anterior temporals; six or seven supralabials; nine infralabials. Scales subimbricate posteriorly, almost smooth or with small short keel or central tubercle. Number of scales on neck 24–27, number of scales at midbody 32–37. Ventrals 278–320. Snout–vent length 808 mm. Tail length 65 mm.

Body yellow or greyish above, yellow-whitish below, with 52–70 dark or black bands. Head dark with flecks of olive or yellowish markings on prefrontal and around eye.

Distribution. The Gulf of Thailand, southern Vietnam, Indonesia (Java, ?Kalimantan), the Arafura Sea, and New Guinea. A rare species in the waters of Vietnam.

References. Rasmussen (2001); Rasmussen et al. (2007, 2011).

***Cbitulia pachycercos* (Fischer, 1855)**

Hydrophis pachycercos Fischer, 1855, S. 44 (Indian Seas).

Types. ZMUC R661230 (neotype).

Maxillare with 7–8 teeth separated by diastema from fangs. *Palatinum* with 7–8 teeth; *pterygoideum* with 17–19 teeth; *dentale* with 16 teeth. Normally two supralabials (third and fourth) bordering eye. Diameter of eye less than distance from eye to mouth corner. One, two or three anterior temporals; one preocular and two or

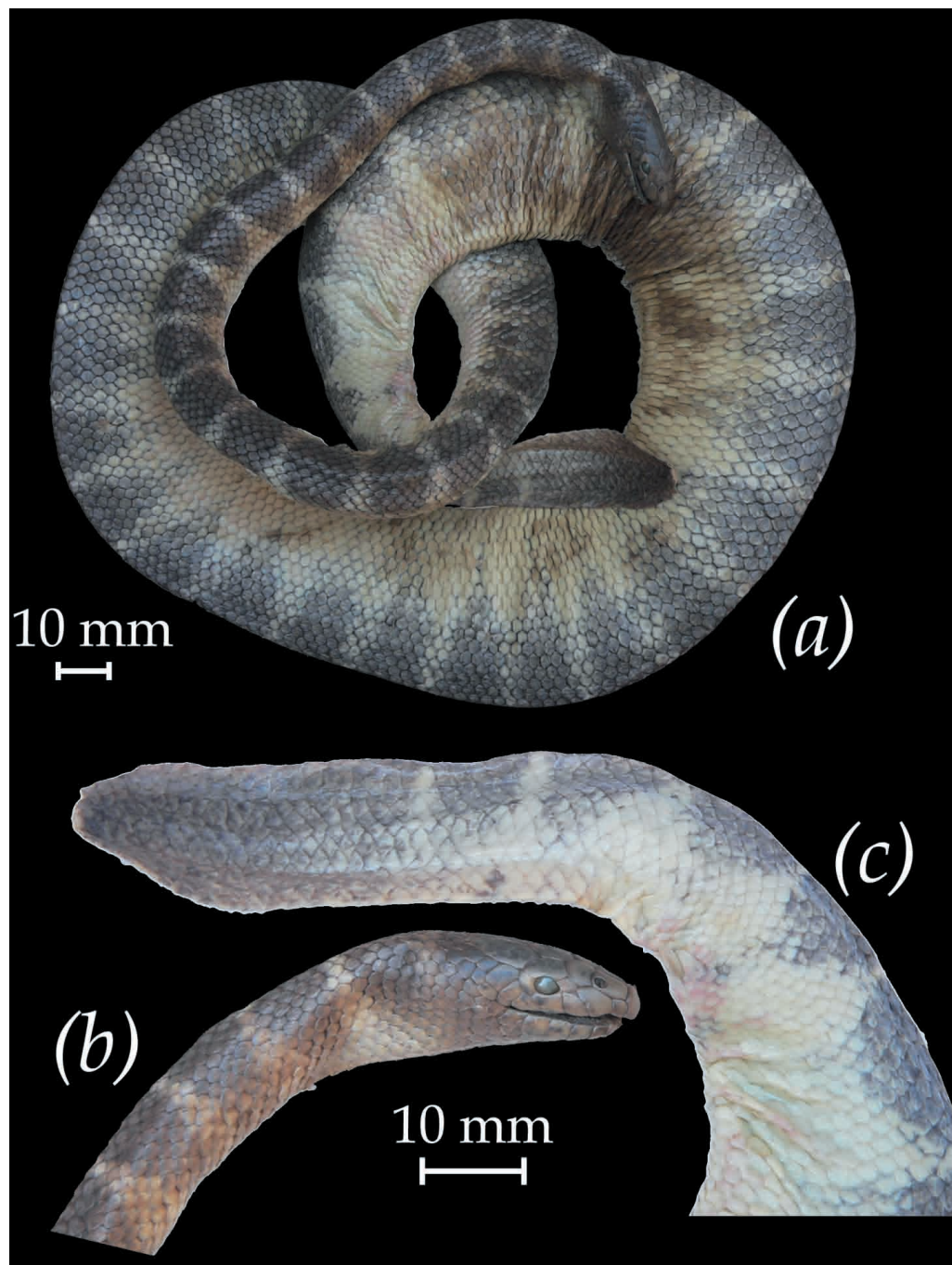


Fig. 47. *Chitulia belcheri* (TINRO R 040), Arafura Sea. The lateral view (a); lateral view of the head (b), the tail (c). After Kharin, Czeblukov (2007).

three postoculars; seven supralabials; eight or nine infralabials. Scales feebly imbricate on neck, juxtaposed on body, with strong keels, each formed of two tubercles. Number of scales on neck 26–31, number of scales on midbody 39–45. Ventrals 247–297. Snout–vent length 820 mm. Tail length 110 mm.

Body pale yellow above, white below, with pale brown transverse bands fading on upper part of flanks. Head white below, black-dark above with pale supralabials and pale ring around eyes.

Distribution. South China Sea. A rare species in the waters of Vietnam.

Remarks. During The Second World War, the type of *Hydrophis pachycercos* (ZMH 390) was destroyed (Kharin, Hallermann, 2009). For many years it was considered to be a synonym of *Aturia belcheri* (M. Smith, 1926), but recently the species has been restored by several specimens from the South China Sea and a neotype was selected (Rasmussen et al., 2007).

References. Rasmussen et al., 2007, 2011.

***Chtulia ornata ornata* (Gray, 1842)**

Figs. 49–51

Aturia ornata Gray, 1842, p. 61 (Indian Ocean).

Hydrophis laevis Lütken, 1862, p. 309, tab. I og II, fig. 6 (origin unknown).

Hydrophis ellioti Günther, 1864, p. 337, pl. xxv, fig. N (Madras, India; Ceylon = Sri Lanka).

Hydrophis godeffroyi W. Peters, 1872, S. 856, taf. I, fig. 3 (Gilbert Islands).

Distira andamanica Annandale, 1905, p. 194 (Andaman Islands).

Hydrophis ornatus maresinensis Mittlemann, 1947, p. 3 (Ishigaki, Riukiu Islands, Japan).

Types. BMNH 1946.1.23.72 (III.3.1a, holotype).

Maxillare with 9–13 teeth separated by diastema from fangs. *Palatinum* with 7–10 teeth; *pterygoideum* with 18–27 teeth; *dentale* with 18–22 teeth. Normally two or three supralabials (third and fourth; or third, fourth, and fifth) bordering eye.

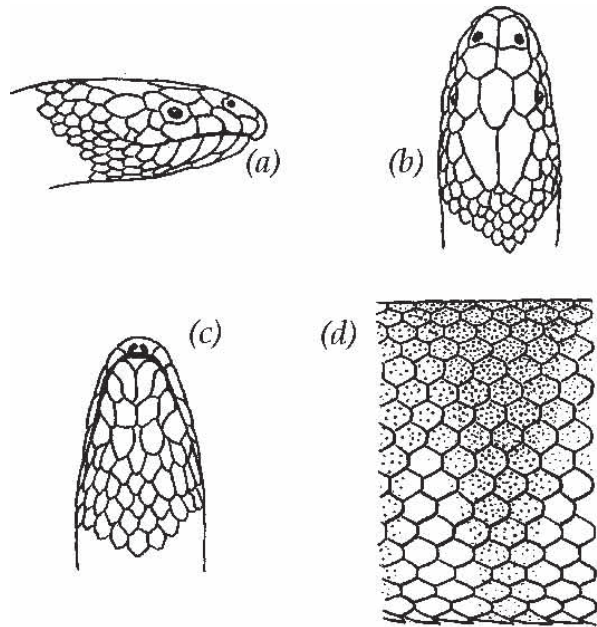


Fig. 48. *Chtulia belcheri*, holotype of *Aturia belcheri*, BMNH 1946.1.97, New Guinea. The lateral (a), dorsal (b) and ventral (c) views of the head; scales of the mid-body (d).

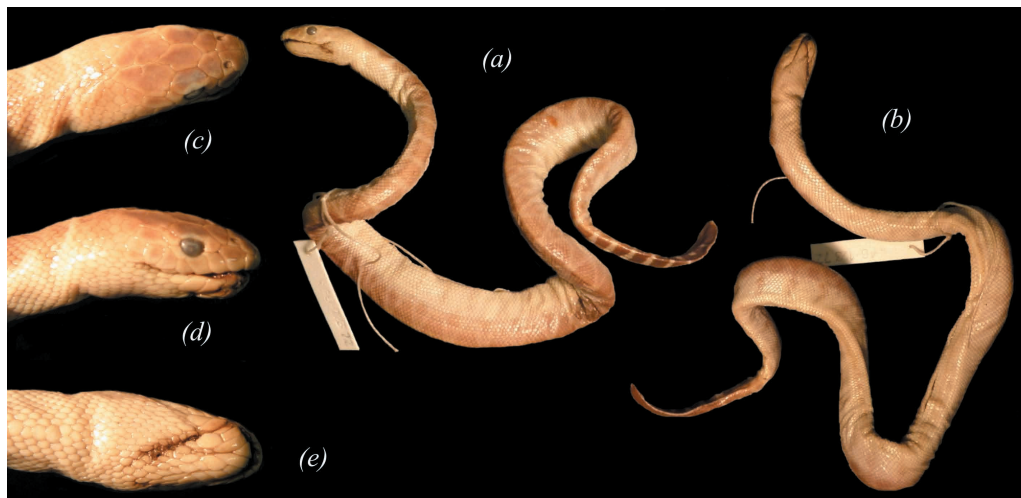


Fig. 49. *Chitulia ornata*, holotype of *Aturia ornata*, BMNH 1946.1.23.72, Indian Ocean. The dorsal (a) and ventral views (b); dorsal (c), lateral (d) and ventral (e) views of the head. Photo by P. Campbell.

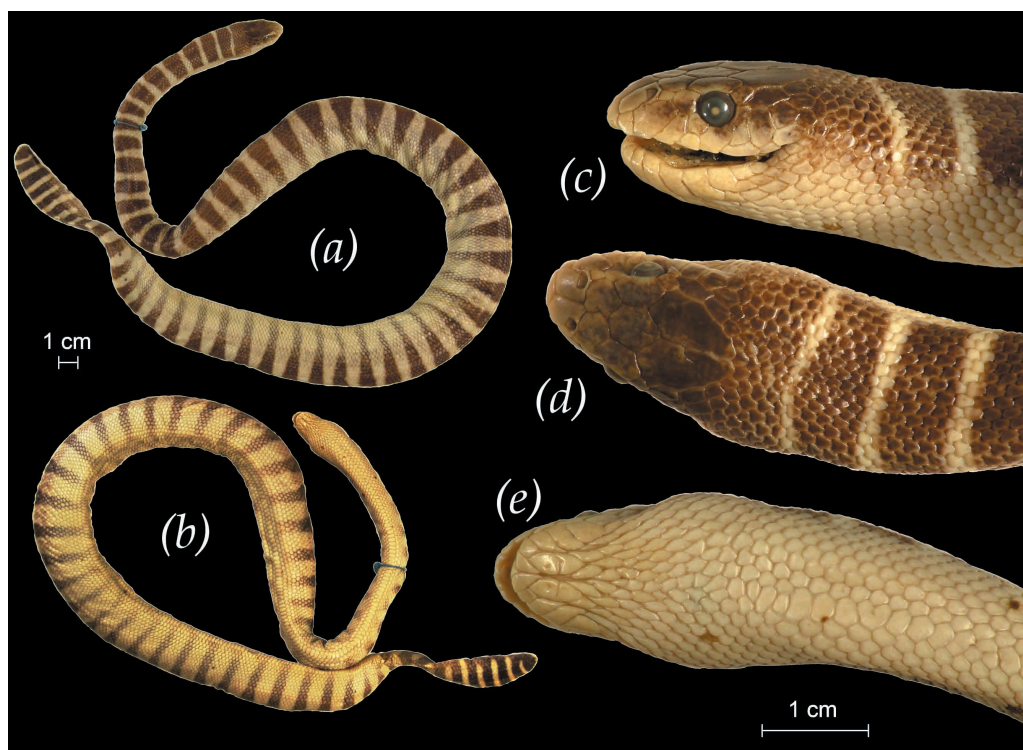


Fig. 50. *Chitulia ornata*, syntype of *Hydrophis godeffroyi*, ZMB 7593, Gilbert Islands. The dorsal (a) and ventral views (b); dorsal (c), lateral (d) and ventral (e) views of the head. After Kharin (2008).

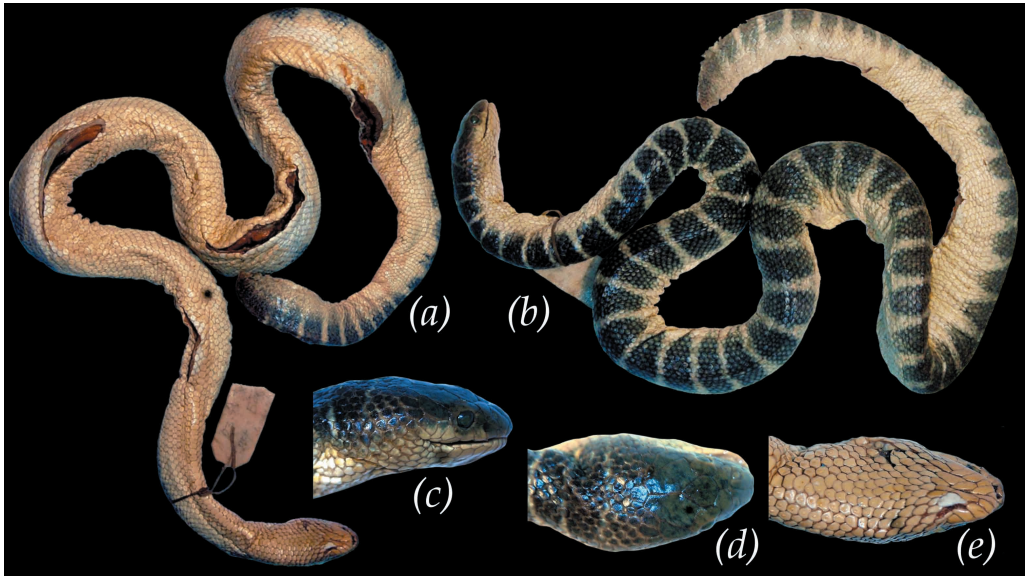


Fig. 51. *Chitulia ornata* (ZMNMNH 1926/4530), South Vietnam. The ventral (a) and dorsal (b) views. The lateral (c), dorsal (d) and ventral (e) views of the head. Photos by I.B. Dotsenko and V.I. Radchenko.

One preocular and two or three postoculars; one, two or three anterior temporals; six to eight supralabials; nine to twelve infralabials. Single or series of small cuneated scales at oral margin after second, third or/and fourth infralabials. Diameter of eye subequal to distance from eye to mouth corner. Number of scales on neck 28–37 in males and 31–45 in females; number of scales on midbody 33–45 in males and 39–55 in females. Body scales often with tubercles or short keels. Ventrals 209–260 in males and 236–312 in females. Snout–vent length 835 mm in males and 780 mm in females. Tail length 115 mm in males and 80 mm in females.

Body pale grey or olive above and whitish below, with dark rhomboid blotches or cross bands. Cross bands broader than spaces between them on dorsal side, but narrower than these spaces on lateral sides. Head olive. Dorsal part of body with parallel bands anteriorly and normally interspaces up to two scales wide.

Distribution. *C. ornata ornata* is distributed in Persian Gulf, the waters of Pakistan, India, Ceylon, Burma, Thailand, Malaysia, Vietnam, China (to Hong Kong), as far north as southern Japan (Honshu and Ryukyu islands), the waters of Indonesia, and the Philippines. A common species in the waters of Vietnam.

Remarks. The species can be differentiated into 3 or 4 subspecies according to different data (Mittleman, 1947; Klemmer, 1963), but many herpetologists do not accept this differentiation (e.g. Rasmussen, 1989). The Australian population

apparently presents a separate species *C. ocellata* (Gray, 1849) (Kharin, 2005) or a subspecies *C. ornata ocellata* (Rasmussen, 2001).

References. Mocquard (1906); M. Smith (1926, 1943); Bourret (1934, 1936); Shuntov (1962, 1966); Pickwell (1972); Bùi Văn Du'ng (1978); Tran, Nguyễn (1980); Kharin (1984b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Dotsenko (1999, 2003); Rasmussen (2001); Nguyễn et al. (2005); Nguyễn et al. (2009); Rasmussen et al. (2011).

Chitulia lamberti (M. Smith, 1917)

Fig. 52

Hydrophis lamberti M. Smith, 1917, p. 340 (from Mekong River, Gulf of Thailand).

Types. BMNH 1946.1.9.20 (formerly 1921.2.11.13, holotype).

Maxillare with 9–12 teeth separated by diastema from fangs. *Palatinum* with 7–8 teeth; *pterygoideum* with 18–20 teeth; *dentale* with 18–20 teeth. Normally two supralabials (third and fourth) bordering eye. One preocular and two or three postoculars; one, two, or three anterior temporals; six to eight supralabials; nine to eleven infralabials. Single or series of small cuneated scales at oral margin after third or/and fourth or/and fifth infralabials. Diameter of eye subequal to distance from eye to mouth corner. Number of scales on neck 38–42 in males and 37–45 in females; number of scales on midbody 45–52 in males and 49–56 in females. Body scales often with tubercles or short keels. Ventrals 258–305 in males and 273–306 in females.

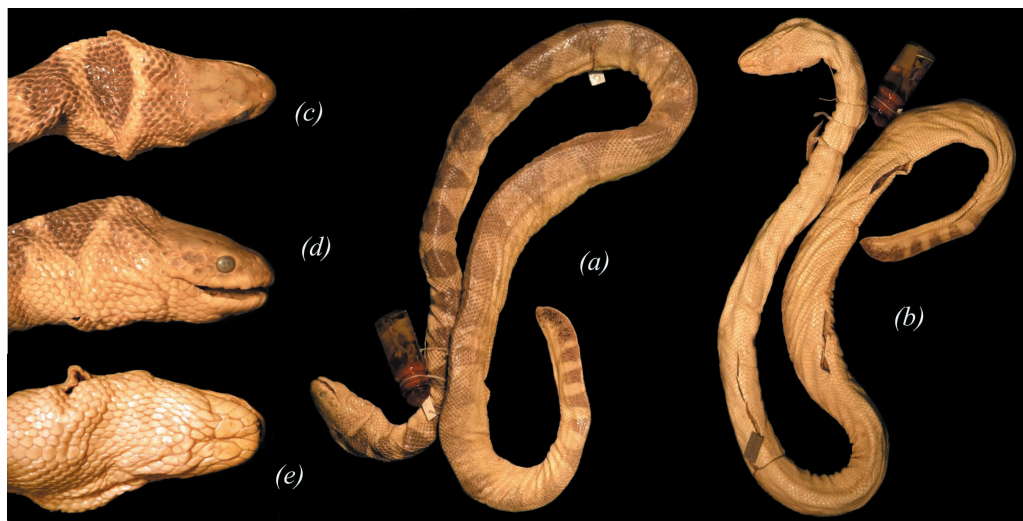


Fig. 52. *Chitulia lamberti*, holotype of *Hydrophis lamberti*, BMNH 1946.1.9.20, from the Mekong River, Gulf of Thailand. The dorsal (a) and ventral views (b); the dorsal (c), lateral (d) and ventral (e) views of the head. Photo by P. Campbell.

Body whitish or pale grey above, paler below. Large rounded dorsal bands anteriorly, posteriorly gradually becoming narrower and separated by broader interspaces. Bands broader above, narrow and faintly coloured laterally. Dorsal part of body with rounded bands anteriorly, the interspaces more than two scales wide.

Distribution. Singapore, the Gulf of Thailand, Vietnam, and the Philippines. A rare species in the waters of Vietnam.

References. Rasmussen et al. (2001, 2007, 2011); Kharin (2006); Nguyễn et al. (2009).

***Chitulia inornata* (Gray, 1849)**

Figs. 53, 54

Chitulia inornata Gray, 1849, p. 56 (Indian Ocean).

Chitulia fasciata Gray, 1849, p. 56 (Indian Ocean).

Thalassophis schlegelii P. Schmidt, 1852, S. 83, Taf. v (Java, Indonesia).

Hydrophis manilae Owen, 1859, p. 77 (Philippines, *nomen nudum*).

?*Hydrophis controversa* Jan p. 50 (origin unknown, *nomen dubium*).

Hydrophis longiceps Günther, 1864, p. 375, pl. xxv, fig. O (Indian Ocean).

Distira cyanosoma Wall, 1913, p. 516 (Philippines, Manila Bay).

Types. BMNH 1946.1.27 (formerly III.7.1.a, holotype).

Maxillare with 8–12 teeth separated by diastema from fangs. **Palatinum** with 7–8 teeth; **pterygoideum** with 20–21 teeth; **dentale** with 17 teeth. Normally two supralabials (third and fourth) bordering eye. One preocular and two postoculars; two anterior temporals; seven or eight supralabials; nine infralabials. Diameter of eye subequal to distance from eye to mouth corner. Body scales often with tubercles or short keels. Number of scales on neck 29–34; number of scales on midbody 42–49. Ventrals 214–279. Snout–vent length 881 mm; tail length 90 mm.

In living snakes entire upper side, from head to tail, black; lateral and lower sides light yellow (reddish in fixed specimens). Maxillary shields light colored. Young specimens have obscure transverse bands across lateral sides of body. Tail black.

Distribution. The Arabian Sea, around the Philippines, the coastal waters of Java, and the shelf of Northern Australia. M. Smith (1926) mentioned two specimens from Tsingtau (Qingdao), China (the Yellow Sea), which makes possible its penetration to the waters of Vietnam.

***Chitulia lapemoides* (Gray, 1849)**

Fig. 55

Aturia lapemoides Gray, 1849, p. 46 (Ceylon = Sri Lanka; Madras, India).

Hydrophis holdsworthii Günther, 1872, p. 33 (Ceylon = Sri Lanka).

?*Hydrophis stewartii* Anderson, 1872, p. 399 (Orissa, India).

Types. BMNH 1946.1.7.2 (formerly III.3.3.a) and 1946.1.6.91 (formerly III.3.3.b), two syntypes.

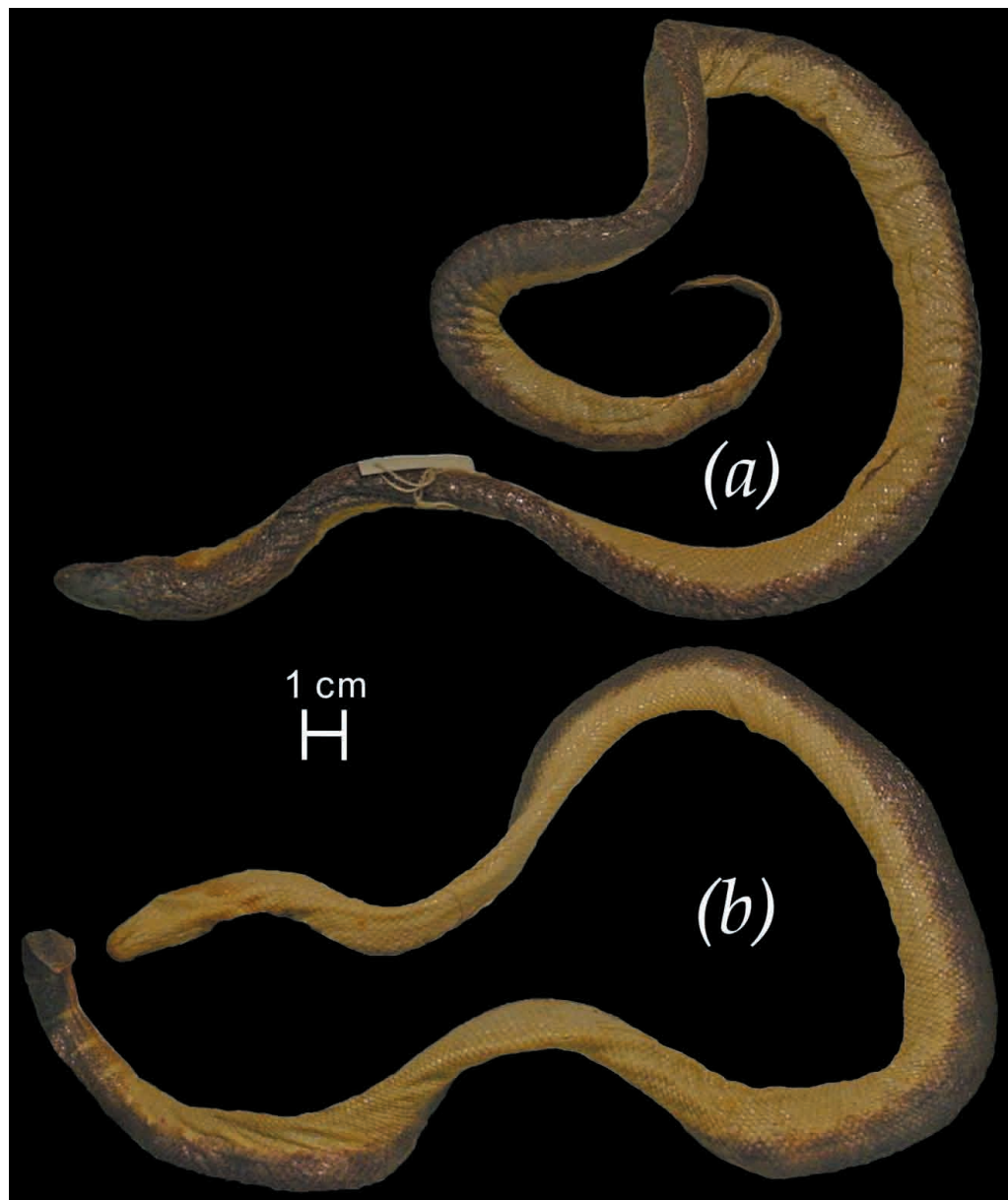


Fig. 53. *Cbitulia inornata*, holotype, BMNH 1946.1.27, Indian Ocean. The dorsal (a) and ventral views (b). Photo by C.J. McCarthy.

Maxillare with 8–13 teeth separated by diastema from fangs. *Palatinum* with 7–10 teeth; *pterygoideum* with 21–26 teeth; *dentale* with 20–23 teeth. Normally two supralabials (third and fourth) bordering eye. One preocular and two or three

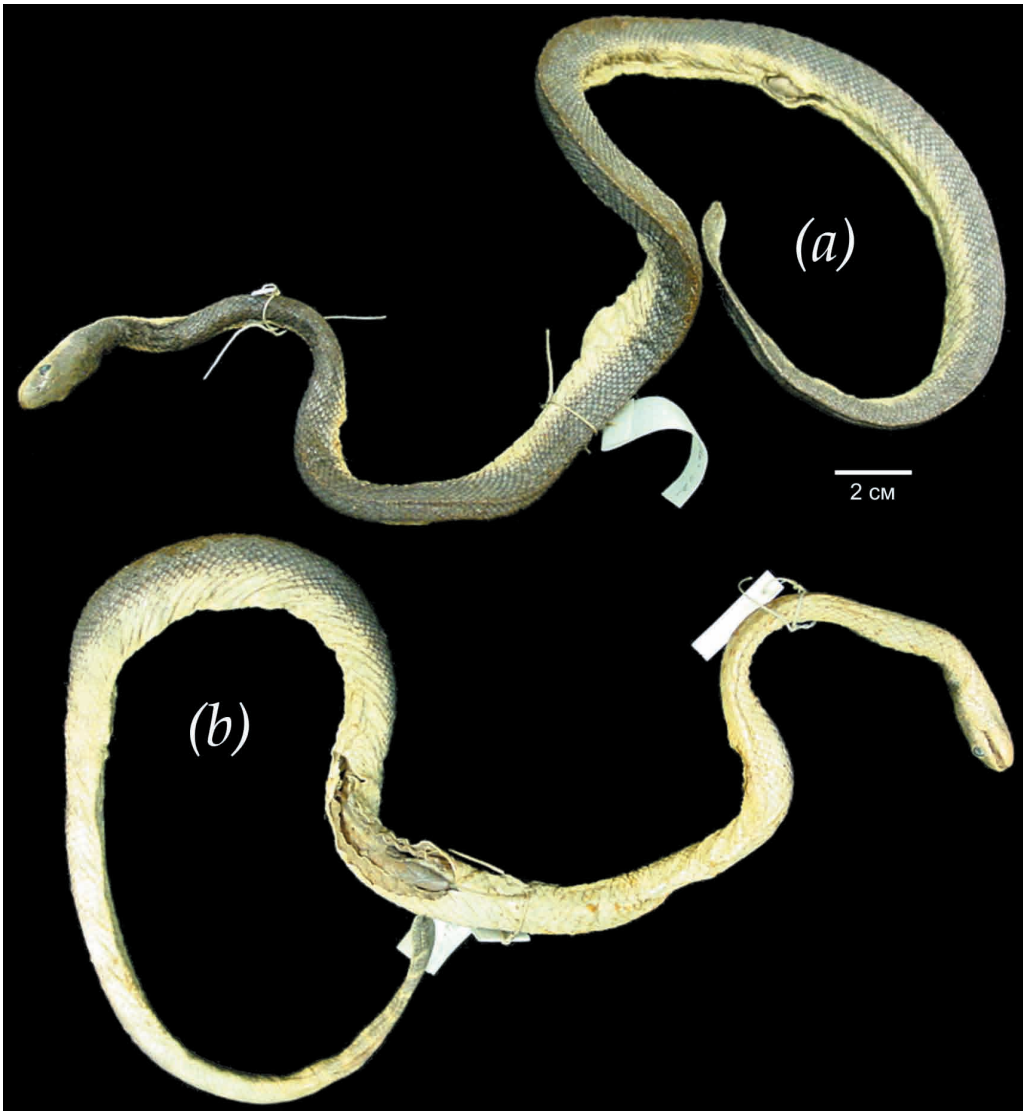


Fig. 54. *Chitulia inornata*, holotype of *Distira cyanosoma*, BMNH 1946.1.1.58, Philippines, Manila Bay. The dorsal (a) and ventral views (b). Photo by C.J. McCarthy.

postoculars; two or three anterior temporals; eight supralabials and eight or nine infralabials. Series of small cuneated scales at oral margin after second or third infralabial. Diameter of eye equal to distance from eye to mouth corner. Posterior scales hexagonal or more or less quadrilateral in shape, juxtaposed or very feebly imbricate, with feeble tubercle or short central keel in adult females, with strong spinose tubercle in adult males. Number of scales on neck 28–34 in males and 28–35

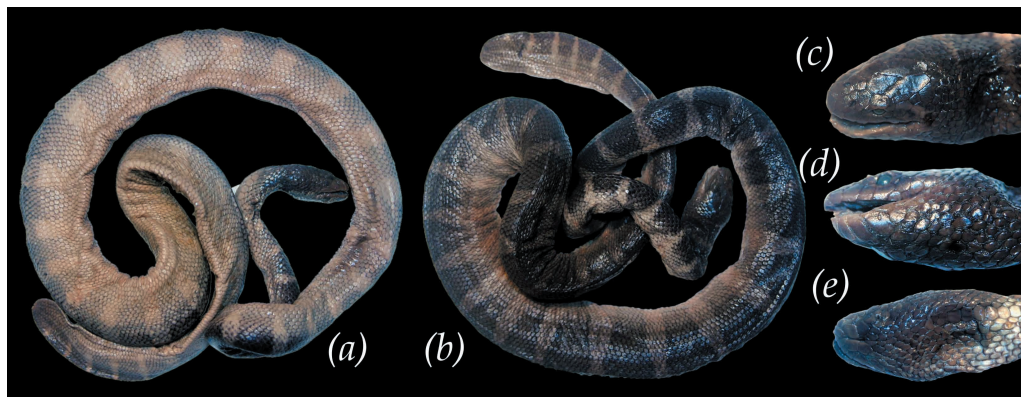


Fig. 55. *Cbitulia lapemoides* (ZMNMNH 1927/4719), South Vietnam. The ventral (a) and dorsal (b) views. The dorsal (c), lateral (d) and ventral (e) views of the head. Photos by I.B. Dotsenko and V.I. Radchenko.

in females; number of scales on midbody 40–51 in males and 41–57 in females. Ventrals 288–365 in males and 293–395 in females. Snout–vent length 870 mm in males and 855 mm in females. Tail length 90 mm in males and 70 mm in females.

Head dark dorsally with curved white mark above, starting from forehead and going back, yellowish ventrally; some older specimens without curved mark. Body with 29–52 black bands forming rhombic spots dorsally and disappearing with age ventrally. Tail with 3–5 black bands.

Distribution. Persian Gulf, the Gulf of Oman, India, Sri Lanka, the Andaman Sea, the Strait of Malacca, the Gulf of Thailand. Only one record in the waters of Vietnam (ZMNMNH 1927/4719, Vietnam, Dong Nai, estuary of Saigon River).

Remarks. It is also possible that *H. stewartii* Anderson, 1872, which is considered as a junior subjective synonym of *A. lapemoides*, is indeed a valid taxon (Rasmussen, 1993; Kharin, Czeblukov, 2007; Kharin, Dotsenko, 2012).

References. Dotsenko (1999, 2003) (as *Hydrophis ornatus*, only ZMNMNH 1927/4719).

Genus *Polyodontognathus* Wall, 1921

?*Polyodontes* Lesson in Bélanger, 1834, p. 325 (type *Polyodontes annulatus* Lesson in Bélanger, 1834 = ?*Hydrus caeruleus* Shaw, 1802), *nomen praeoccupatum* (non Blainville, 1829, Polichaeta).

Polyodontognathus Wall, 1921, p. 374 (type *Hydrus caeruleus* Shaw, 1802, by monotypy).

Diagnosis. *Maxillare* longer than *ectopterygoideum*, its anterior part not arcuate, extending forward beyond *palatinum*. tip of fang projecting conspicu-

ously below line connecting tips of maxillary teeth. *Palatinum* without triangular flange for *maxillare*, only with tubercle-like convexity. *Maxillare* with 12–18 teeth separated by diastema from fangs. *Palatinum* with 7–8 teeth; *pterygoideum* with 19–27 teeth; *dentale* with 22–26 teeth. *Quadratum* with slight backward inclination (nearly vertical). *Frontale* excluded from orbit border. *Parietale* with sagittal crest; *parietale* articulated with postorbital excluding *frontale* from border of orbit. *Angulare* equal to *spleniale*. *Spleniale* without foramen. *Basisphenoideum* with median keel and broadly entering ventral margin of anterior orifice of *cavum epiptericum*.

Rostral scute with median fold on anterior margin fitting into median notch in mental and completely dividing lingual fossa of rostral into separate left and right grooves. Preocular always present. Posterior chin shields separated by mental groove. Anterior temporals always 1–3 in number.

The genus is monotypic, with two subspecies.

***Polyodontognathus caerulescens hybridus* (Schlegel, 1844)**

Hydrophis hybrida Schlegel, 1844, S. 115, Taf. xxxviii (Moluccas, Indonesia).

Hydrophis protervus Jan, 1959, p. 149 (origin unknown).

Hydrophis caerulescens thai M. Smith, 1920, p. 18 (Hua Hin, Gulf of Thailand).

Type s. RMNH 1492 (holotype).

One preocular and one or two postoculars; two or three anterior temporals; seven or eight supralabials; supralabials 3 and 4 in contact with eye; eight or nine infralabials; cuneate scales appear behind third or fourth infralabials. Diameter of eye equal to or greater than its distance from mouth. In 65 % of specimens parietal scute in touch with postorbital scute. Posterior scales subimbricate and with truncated tips, all strongly keeled. From 31 to 39 scales on neck, from 37 to 49 scales on midbody. Ventrals 225–334. Snout–vent length: 720 mm in males and 675 mm in females. Tail length: 100 mm in males and 65 mm in females.

Body bluish-grey above, greyish below, with 40–60 dark or black bands, broader than interspaces between them. Bands become indistinct and body become almost uniformly greyish blue with age.

Distribution. The Gulf of Thailand, the South China Sea, the Yellow Sea, Indonesia, and the Arafura Sea. A common species in the waters of Vietnam.

References. M. Smith (1926, 1943); Bourret (1934, 1936); Bùi Văn Du'ng (1978); Kharin (1984b, 2004b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Nguyễn et al. (2005); Rasmussen et al. (2007); Nguyễn et al. (2009); Rasmussen et al. (2011).

Tribe **Disteirini** Kharin in Kharin et Czeblukov, 2009

Disteirini Kharin in Kharin, Czeblukov, 2009, p. 184.

Depressor mandibulae with occipital head, originating from transverse occipital crest near midline posterior or posteromedial to origin of *adductor mandibulae externus medialis*, its fibers passing posterior to those of quadrate head of *depressor mandibulae*. *Adductor mandibulae externus superficialis* with very broad dorsal portion that completely conceals *adductor externus medialis* and originates from entire length of *parietale* and from transverse occipital crest (unique in Hydrophiidae). *Adductor mandibulae externus superficialis* passing over anterodorsal corner of *quadratum*, but unattached to that bone, except in *Astrotia stokesii*.

The tribe Disteirini comprises three genera: *Astrotia* Fischer, 1856, *Disteira* Lacépède, 1804, and *Enhydrina* Gray, 1849.

Genus *Astrotia* Fischer, 1856

Astrotia Fischer, 1856, p. 38 (type *Hydrophis schizopholis* P. Schmidt, 1846 = *Hydrus stokesii* Gray in Stokes, 1846, by monotypy).

D i a g n o s i s. *Maxillare* with teeth separated by diastema from fangs and not extending forward beyond *palatinum*. *Maxillare* with 6–8 teeth, *palatinum* with 7–9 teeth, *pterygoideum* with 19–21 teeth, *dentale* with 18–22 teeth. *Squamosum* widely inserted in *parietale*, forming almost rectangular deep cavity. *Palatinum* teeth similar to *pterygoideum* teeth. *Nasale* sutured to *praefrontale* and *frontale*, longer than *frontale*. *Praefrontale* meeting *parietale* and *postorbitale*. *Frontale* broader than long, meeting *postorbitale* at rim of orbit. *Parietale* not keeled inferiorly. *Quadratum* oblique from above backwards, extreme length superiorly about equals half its depth. Caudal vertebrae with paired haemapophyses feeble and not enclosing caudal vessels in haemal canal, but with median hypapophysial keel or process. *Adductor externus superficialis* passing over antero-dorsal corner of *quadratum* and attached to that bone.

The genus comprises one species.

Astrotia stokesii (Gray, 1846)

Figs. 56–58

Hydrus stokesii Gray, 1846b, p. 502, pl. iii (Australian Seas).

Hydrus annulatus Gray, 1849, p. 59 (Singapore).

Hydrophis schizopholis P. Schmidt, 1846, S. 166, taf. xv (China Sea).

Hydrophis güntheri Theobald, 1866 (non Murray, 1884), p. 69 (Hoogly River, India (as Sandheads), *nomen praeoccupatum*).

Hydrophis granosa Anderson, 1871, p. 190 (mouth of Hooghly River, India (as Sandheads)).

Hydrophis guttata Murray, 1887, p. 34 (Makran coast, Iran and Pakistan).



Fig. 56. *Astrotia stokesii*, holotype of *Hydrophis schizopholis*, ZMH R 01154, China Sea. The dorsal (a) and ventral views (b). After Kharin and Czeblukov (2009).



Fig. 57. *Astrotia stokesii*, holotype of *Hydrophis guttata*, BMNH 1946.1.19.73, Mekran coast, India. The dorsal (a) and ventral views (b). After Kharin and Czeblukov (2009).

Type s. BMNH 1946.1.17.12 (formerly III.9.1.d, holotype).

Diameter of eye equal to or less than its distance from mouth. One preocular and two postoculars; two or three anterior temporals; eight to ten supralabials; supralabials 4 to 6 usually in contact with eye; ten to twelve infralabials; no distinct sublinguals. Scale rows 37–47 on neck, 46–63 on midbody; scales strongly imbricate, pointed, keeled; keel often broken up into tubercles. Ventrals 226–286.

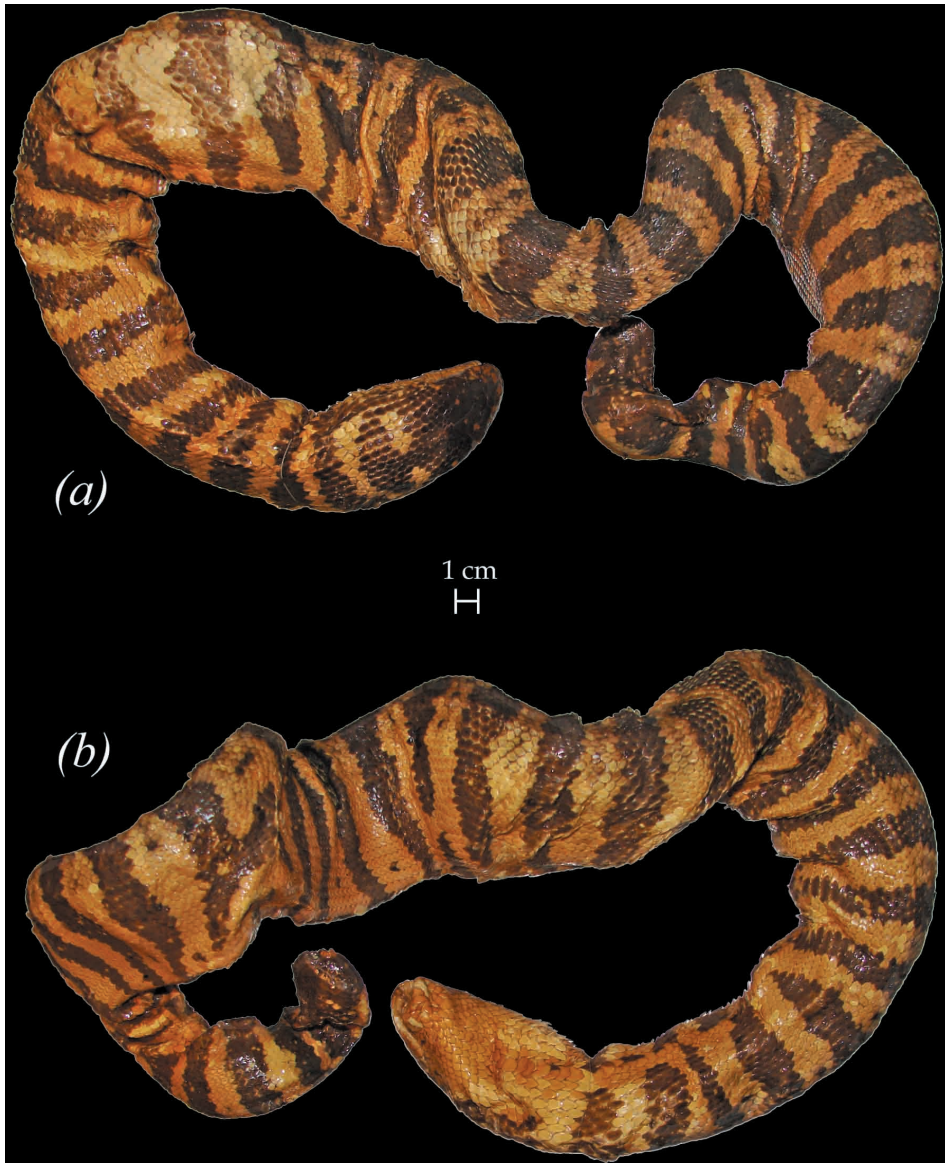


Fig. 58. *Astrotia stokesii*, holotype of *Hydrus annulatus*, BMNH1946.1.19.74, Singapore. The dorsal (a) and ventral (b) views. After Kharin and Czeblukov (2009).

All ventrals behind throat divided into pair of foliiform or pointed scales, forming strongly raised ventral keel (Fig. 5) except in juvenile specimens. Preanal strongly enlarged. Snout–vent length 1030 mm (males) and 1410 mm (females). Tail length 170 (males) and 190 (females).

Yellowish or pale brown, with broad black or dark brown bands more or less complete, or with dorsal bars and ventral spots. Spots or narrow bars often present between cross bands. Head dark olivaceous to yellowish. Another form of species has 32–36 more or less complete dark bands.

Distribution. Persian Gulf, the Arabian Sea, Pakistan, India, Sri Lanka, Malaysia, Singapore, the Gulf of Thailand, Vietnam, South China, Taiwan, the Philippines, Indonesia, and Australian region (except for Western Australian waters).

References. Kharin (1984b, 2006); Rasmussen (2001); Nguyễn et al. (2009); Kharin, Czeblukov (2009); Rasmussen et al. (2011).

Genus *Enhydrina* Gray, 1849

Enhydrina Gray, 1849, p. 47 (type *Enhydrina valakadyen* Gray, 1849 = *Hydrus valakadyen* F. Boie, 1827 = *Hydrophis schistosus* Daudin, 1803, by subsequent designation – Klemmer, 1963).

Diagnosis. *Maxillare* with teeth separated by diastema from fangs and not extending forward beyond *palatinum*. *Maxillare* with 3–5 teeth, *palatinum* with 5–6 teeth, *pterygoideum* with 15–17 teeth, *dentale* with 15–16 teeth. *Squamosum* slightly inserted in *parietale*, never forming almost rectangular deep cavity. *Palatinum* teeth conspicuously larger than *pterygoideum* teeth. *Nasale* not sutured to *praefrontale* or *frontale*, confluent posteriorly (feature unique among Hydrophiidae), longer than *frontale*. *Praefrontale* not meeting *parietale*, meeting *postorbitale*. *Frontale* as broad as long, meeting *postorbitale* at rim of orbit. *Parietale* strongly keeled inferiorly. *Quadratum* oblique from above backwards, extreme length superiorly equals half its depth. Caudal vertebrae with paired haemapophyses feeble and not enclosing caudal vessels in haemal canal, but without median hypapophysial keel or process (except for *E. zweifeli*). *Adductor externus superficialis* passing over antero-dorsal corner of *quadratum* and unattached to that bone.

Mental shield elongate, several times longer than broad and partly hidden in groove in symphysis (Fig. 3). Scale rows 40–55 on neck, 49–66 on midbody. Ventral scute series usually interrupted irregularly by median longitudinal division of ventrals into pointed scales.

There are two species in the genus.

Enhydrina schistosa (Daudin, 1803)

Figs. 59, 60

Hydrophis schistosus Daudin, 1803, p. 386 (based on Russell's fig. x, Tranquebar, India).

Hydrophis valakadyen F. Bie, 1827, S. 554 (based on Russell's fig. xi, Tranquebar, India).

Disteira russelli Fitzinger, 1827, S. 733 (based on Russell's fig. xi, Tranquebar, India).

Hydrophis subfasciata Gray, 1842, p. 62 (Bengal, India and Bangladesh).

Hydrophis bengalensis Gray, 1842, p. 62 (Bengal, India and Bangladesh).

Thalassophis werneri P. Schmidt, 1852, S. 85, Taf. vi (Semarang, Java, Indonesia).



Fig. 59. *Enhydrina schistosa*, syntype of *Hydrophis subfasciata*, BMNH 1946.1.1.90. Bengal, India and Bangladesh. The dorsal (a) and ventral (b) views. After Kharin and Czeblukov (2009).



Fig. 60. *Enhydrina schistosa* (FMNH 198706), Muar, Malaysia. Photo by H.K. Voris.

Type s. BMNH 1946.1.10.7 (formerly 1921.7.28.1, holotype)

Diameter of eye about equal to its distance from mouth. One preocular, sometimes two, postoculars; usually single anterior temporal; seven to eight supralabials; supralabials 3 and 4, or only 4, in contact with eye; last two or three ones very small; eight or nine infralabials; usually single anterior temporal. Mental narrow, elongated, and hidden in groove. Scale rows around neck 40–52 (males) and 42–55 (females); scale rows around body 49–60 (males) and 51–66 (females). Scales subimbricate or imbricate, with short central keel. Ventrals 239–322, distinct throughout, a little broader than adjacent scales. Preanals feebly enlarged. Snout–vent length 1220 mm and tail length 180 mm.

Adults more or less uniform gray above, whitish below. Dark bars as wide as or much wider than paler interspaces. Head dark gray above, pale below. Young specimens having dark gray or black annuli or 45–55 transverse bars, which scarcely extend more than half-way down the flanks; lower half of body whitish, without pattern.

Distribution. Persian Gulf, the Arabian Sea, Madagascar, Iran, Pakistan, India, Sri Lanka, Malaysia, Singapore, the western coast of Thailand, the Gulf of Thailand, Vietnam, Indonesia, and Australian region (including the waters of New Guinea Island; except for Western Australian waters).

References. Mocquard (1906); M. Smith (1920, 1926, 1943); Bourret (1934, 1936); Shuntov (1962, 1966); Pickwell (1972); Tran, Nguyễn (1980); Kharin (1984b, 2006); Tran, Nguyễn (1995); Nguyễn, Hó (1996); Nguyễn et al. (2005); Kharin, Czeblukov (2009); Nguyễn et al. (2009); Rasmussen et al. (2011).

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Reef-building corals of Vietnam as a part of the Indo-Pacific reef ecosystem

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Abstract: The paper analyzes both published and unpublished results of the investigations of Vietnamese reef building corals and reefs performed in the last decades of the twentieth century. The state of the art in the study of reef-building scleractinian corals and reefs is presented. The scleractinian fauna of Vietnam is shown to match in species diversity (376 species of 80 genera) the tropical coral fauna of the Indonesian–Malacca fertile center, from which Indo-Pacific reef-building corals originated. The entire Vietnam coast from the Gulf of Tonkin to the Gulf of Thailand (Siam) is a biogeographically single whole and is a part of the Indo-Polynesian Province of the Indo-Pacific Area.

Key words: Vietnam, reefs, reef-building corals, biodiversity, biogeography.

The coastline of Vietnam is over 3200 km long and covers 15 degrees in latitude, from the Gulf of Siam (or Gulf of Thailand) in the south (8° N) to the Chinese border in the north (23° N). The nearshore water area (up to 50-m deep) of Vietnam, including some 3000 islands, is about 206000 km². Vietnam and its coastline are divided into five parts, the Gulf of Tonkin (or Beibu Gulf), Central and Southern Vietnam, the Gulf of Siam, and the Spratly Islands (Thanh, 1999). Reef-building corals and reef accumulations are confined to hard bottoms, typical of the Vietnam coast. Between 16° and 19° N, the coastline is formed mostly by moving sand with a minor presence of hard bottoms. The temperature varies between 18–32°C, and the salinity, 28–40‰. One hundred and fourteen rivers are registered along the coastline. The spread of the reefs is limited near the mouths of two large rivers, the Red River in the north and the Mekong in the south, due to adverse conditions. The ecosystems of the coral reefs of Vietnam feature high bioproductivity, with a primary production of up to 30–100 mg C/m³ per day, which is almost 100 times that in open waters (Sorokin, 1986; An, 1994).

Vietnam is situated in the tropics, affected by two sorts of monsoons: the wet southwest, lasting from May till September, and the dry northeast, occurring in October–April. Heavy rain showers during the wet monsoon period result in a huge

(5–400 million m³) freshwater influx and a substantial (up to 200 thousand tons) terrigenous sediment influx into the sea. The daily suspended matter precipitation rate in the reef reaches 70–100 g/m² and increases tenfold during typhoons (Vo, Hodgson, 1997; Dautova et al., 1999). This results in a remarkable decrease in water transparency, affecting, together with other factors, the development of coral settlement in this region.

The reef-building corals and reefs of Vietnam attracted scientific attention as early as the first half of the twentieth century (Sérene, 1937; Dawydoff, 1952). Loi (1967) was the first to analyze the zonation of reef-building corals in reefs of the Khanh Hoa Province. He distinguished four scleractinian-dominated facies. These researchers determined the species composition of scleractinians and demonstrated its similarity to that of Australia and Indonesia. Beginning in 1980, systematic studies of Vietnam corals and reefs have been performed in joint expeditions by the Institute of Marine Biology of the then Far Eastern Science Center, USSR Academy of Sciences (Vladivostok), Institute of Oceanography, Vietnam Academy of Sciences and Technology (Nha Trang), Haiphong Institute of Oceanology, and WWF (World Wildlife Fund). The published results were mainly related to scleractinian composition and distribution, with some papers analyzing common accompanying macrobenthos species and a few publications providing the general characteristics of the reefs. Part of the data obtained was presented only in unpublished reports. Some findings were published in difficult-to-obtain regional papers and books, including Vietnamese ones.

To date, in a region bordered by the Gulf of Tonkin in the north, the Gulf of Siam in the south, and the Spratly Islands in the South China Sea, all reef-building areas including large islands and shoals have been studied (Fig. 1).

It is thus topical to review the data available on the coral composition, distribution and development of Vietnam's reefs, as well as on their relation to the Indo-Pacific reef ecosystem. The rapid growth of the country's population of 70 million, together with travel industry development and marine aquaculture intensification (Cheung, 1994), has resulted in increased anthropogenic pressure on this unique ecosystem. Generalizing data on the composition, structure, and environmental conditions of Vietnam's reef communities will allow one to evaluate the degree of their degradation and the outlook for their conservation and recovery.

Both along the coastline and around the islands, reef-building corals form diverse reef topographies. These include small fringing reefs along the coastline, barrier reefs separated from the continent (Re Island and Jang Bo Reef), and atolls (Spratly Islands) in the open South China Sea (Latypov, 1990, 2007, 2008; Ken, 1991; Yet, 1997). Vo and Hodgson (1997) reported Vietnam's reefs to include both true reef frameworks and coral gardens. Various calcareous structures occurring

on reefs might be formed by coral settlements, usually called coral layers, communities, or specialized settlements. Such structures are typical of early reef development stages and lack any geomorphological and vertical biological zonation (Habbard, 1974; Pichon, 1974; Loya, 1976a; Latypov, 1995, 1997). All Vietnam reefs display distinct biological and more or less prominent morphostructural zonation. By the specificity of geomorphological and climate conditions, Vietnam's fringing reefs are clearly distinguished into two types (Fig. 2).

Reefs of the **first type** have a distinct zonation (reef lagoon, reef flat, etc.) with a developed carbonate framework, so-called structural reefs (Wainwrite, 1965), common for the tropical zone of the World Ocean. Reefs of the **second type** display a weak morphostructural zonation, with some zones occasionally absent. Carbonate deposits in such reefs comprise only coral settlements of low thickness, hardly changing the overall substrate profile. These are so-called structureless (Wainwrite, 1965) or encrusting (Latypov, 1995) reefs. Vietnam's structural reefs are mainly formed in closed bights and on the organogenic base of the Holocene reefs (Latypov, 1982; Preobrazhensky, 1986), while structureless reefs are formed off promontories and in open bays, mostly on stone and rocky substrates (Latypov, 1986, 1987, 1995; Yet, Ken, 1996; Yet, 1997).

Vietnam's reefs pertain to the epicontinental monsoon type (Dawydoff, 1952; Latypov, 1982, 1987, 2007; Sorokin, 1990). They are situated at the South China Sea periphery. The shoal waters of this region are highly eutrophicated, and the bottom is highly silted due to the huge amount of terrigenous influx. Other hydrological conditions are also not optimal for reef-building coral growth. Thus, in the Gulf of Tonkin, the salinity may drop to 26‰, and winter water temperature to 16°C.

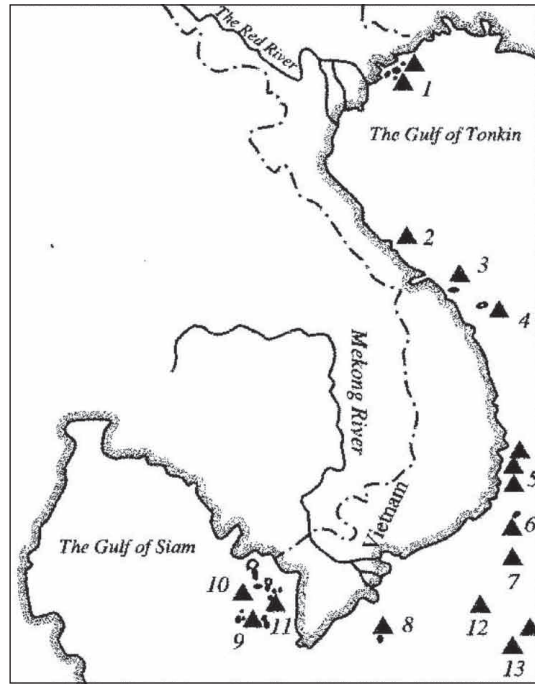


Fig. 1. A schematic map of the surveyed regions. 1 – Bai Tu Long Archipelago, 2 – Ze Island, 3 – Cape Danang, 4 – Cham and Son Tra islands, 5 – Re Island, 6 – reefs of the Khanh Hoa Province, 7 – Thu Island, 8 – Ca Thuik Islands, 9 – Con Dao Islands, 10 – Tho Chu Island, 11 – An Thoi Archipelago and Namsu Islands, 12 – Rach Gia Bay, 13 – Royal Bishop and Astrolab shoals, 14 – Spratly Islands.

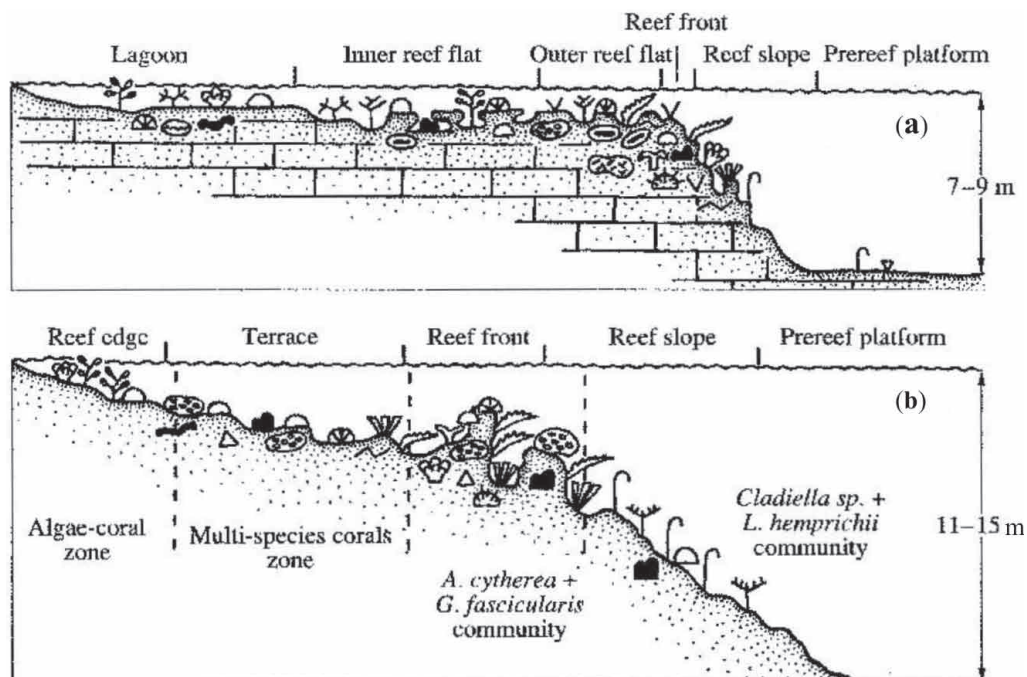


Fig. 2. Schematized profiles of structural (a) and unstructured (b) reefs. See the text for comments.

Heavy northeast monsoon winds generate coastal waves up to three meters high with a 6-s period. During southwest monsoons, the Vietnam coast is struck by 5–10 typhoons per year with the strongest storm excitements and strong desalination that sometimes results in almost utter annihilation of coral reef (Vo, Hodgson, 1997; Latypov, Selin, 2011). All this renders appreciable influence on the formation of reefs which occurs, as a rule, on stony, and rocky-stony substrates and less often on coralogenous sediments of Holocene reefs. Vietnam's reefs feature a moderate vertical and horizontal spread and low thickness of modern reef-derived deposits. Their offshore spread usually does not exceed 200–300 m. They rarely extend to a depth of over 20 m. Sometimes they lack distinct morphological zonation. Most Vietnam's reefs have an indistinct reef flat and slope. In some reefs, mostly ones on stone and boulder substrates, the only distinct zone is a reef slope. However, they all have a distinct vertical biological zonation, showing up in the dominant species succession and in the change in the composition and structure of coral communities and accompanying macrobenthos. Barrier, platform and fringing reefs on Holocene organogenous deposits always have well expressed morphological zonation, characteristic for the majority of Indo-Pacific reefs (Latypov, 2005, 2008; Latypov, Selin, 2008).

According to the studies performed in the first decades of the twenty-first century, Vietnam's reef-building coral fauna comprises 376 species (see Table), pertaining to 80 genera (including 9 ahermatypic corals), of which 137 species, belonging to 26 genera, were not previously known for that region, and 13 species from 6 genera were described for the first time (Latypov, 1987, 1990, 1995, 2003a, b, 2007; Ken, 1991a; WWF Vietnam, 1994; Vo, Yet, 1997; Latypov, Long, 2010). As in most Indo-Pacific reefs (Latypov, 1987, 1997; Best et al., 1989; Veron, Hodgson, 1989; Veron, 1995; Vo, Hodgson, 1997), the species diversity of Vietnam's reefs consists mainly of the members of five families, Acroporidae (117 species), Faviidae (42 species), Fungiidae (32 species), Poritidae (31 species), and Dendrophylliidae (25 species), making up altogether 64.48% of the total scleractinian species composition (Fig. 3). The five genera, most numerous and widespread in all reefs, comprise *Acropora* (90 species), *Montipora* (28 species), *Porites* (20 species), *Favia* (14 species), and *Fungia* (12 species). These genera are also most diverse on all reefs, making 47 % of the total species richness of scleractinians (Fig. 4).

In all, some 20 scleractinian species form monospecific settlements, varying from small "spots" (tens of square meters) to extended zones (hundreds of square meters), with a coverage reaching 60–100%. One fifth of all scleractinians occur throughout the whole length of the Vietnam coast (Fig. 5).

As a whole, the species diversity of reef-building scleractinians in different areas of the Vietnam coast is quite comparable, ranging from 190 species in the Gulf of Tonkin to 265 in the Southern Vietnam (Fig. 6). Similar (193–256) numbers of species were reported for reefs of Indonesia, the Philippines, and Western Australia (Veron, Marsh, 1988; Veron, 1995). Central and Southern Vietnam's reefs are most similar in species composition and are quite comparable to Spratly reefs (Fig. 7). The degree of similarity in the species composition of scleractinians in various areas of Vietnam is shown on the clustered diagram (Fig. 8).

The peculiarity of the coral faunas of the Siam and Tonkin gulfs, as revealed by cluster analysis (Fig. 9), is consistent with peculiar environmental conditions in these water areas (Dawydoff, 1952; Latypov, 1986, 1999, 2000). The diversity of scleractinians is partly caused by similar hydrological regimes in the areas. Both Gulf of Siam and Gulf of Tonkin are shallows with high water eutrophication and turbidity, with a predominance of clay sediments.

These factors cause a similarity in the biological and morphostructural zonation of reefs and species composition of reef communities in the gulfs. At the same time, certain differences in climatic and geomorphological conditions of the gulfs result in some dissimilarities in their scleractinian species composition. The development, zonation, species composition, and structure of the reefs in these water areas were reported previously (Latypov, 1986, 1990, 2000; Sakai et al., 1986; Ken, 1991a), so, only major similarities and differences will be mentioned in the present paper.

List of scleractinian species of Vietnam

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Acantastrea echinata</i> (Dana, 1846)		+	+	+		+	+
<i>Acantastrea hemprichii</i> (Erhenberg, 1834)		+	+	+			+
<i>Acantastrea hillae</i> Wells, 1955		+	+	+			+
<i>Acropora abrolhosensis</i> Veron, 1985	+		+		+		
<i>Acropora abrototonoides</i> (Lamarck, 1816)		+	+	+		+	+
<i>Acropora aculeus</i> (Dana, 1846)						+	
<i>Acropora acuminata</i> (Verril, 1864)	+	+	+			+	
<i>Acropora anthocercis</i> (Brook, 1892)				+		+	
<i>Acropora aspera</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Acropora austera</i> (Dana, 1846)	+	+				+	+
<i>Acropora brueggemanni</i> (Brook, 1893)	+		+			+	
<i>Acropora cerealis</i> (Dana, 1846)	+		+	+		+	+
<i>Acropora clathrata</i> (Brook, 1891)			+		+		
<i>Acropora cytherea</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Acropora dendrum</i> (Bassett-Smith, 1890)				+			
<i>Acropora digitifera</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Acropora divaricata</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Acropora donei</i> Veron et Wallace, 1984			+				
<i>Acropora elseyi</i> (Brook, 1892)		+				+	
<i>Acropora fasciculare</i> Latypov, 1992			+				
<i>Acropora florida</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Acropora formosa</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Acropora gemmifera</i> (Brook, 1892)	+		+	+			+
<i>Acropora glauca</i> (Brook, 1893)	+		+				
<i>Acropora grandis</i> (Brook, 1892)	+	+	+	+	+	+	+
<i>Acropora granulosa</i> (Edwards et Haime, 1860)		+	+	+	+	+	+
<i>Acropora horrida</i> (Dana, 1846)	+				+		
<i>Acropora humilis</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Acropora hyacinthus</i> (Dana, 1846)	+	+	+	+	+	+	+

Table (Continued)

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Acropora insignis</i> Nemenzo, 1967		+				+	
<i>Acropora latistella</i> (Brook, 1892)			+	+			
<i>Acropora listeri</i> (Brook, 1893)			+	+			
<i>Acropora longicyathus</i> (Edwards et Haime, 1860)			+		+		+
<i>Acropora loripes</i> (Brook, 1892)				+			
<i>Acropora lukeni</i> Crossland, 1952	+			+			
<i>Acropora microclados</i> (Ehrenberg, 1834)			+				
<i>Acropora microphthalma</i> (Verril, 1869)			+		+		+
<i>Acropora millepora</i> (Ehrenberg, 1834)	+		+	+	+		+
<i>Acropora monticulosa</i> (Brüggemann, 1879)			+	+			
<i>Acropora multiacuta</i> Nemenzo, 1967				+			
<i>Acropora nasuta</i> (Dana, 1846)		+	+	+	+	+	+
<i>Acropora nobilis</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Acropora palmerae</i> Wells, 1954		+	+				+
<i>Acropora parilis</i> (Quelch, 1886)					+		
<i>Acropora paniculata</i> Verrill, 1902		+				+	
<i>Acropora papillare</i> Latypov, 1992							
<i>Acropora pulchra</i> (Brook, 1891)	+	+	+	+	+	+	+
<i>Acropora pulchra</i> (Brook, 1891)	+	+	+	+	+	+	+
<i>Acropora robusta</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Acropora samoensis</i> (Brook, 1891)				+			
<i>Acropora sarmentosa</i> (Brook, 1891)		+	+	+		+	+
<i>Acropora secale</i> (Studer, 1878)		+		+		+	
<i>Acropora selago</i> (Studer, 1878)	+		+		+		+
<i>Acropora solitariensis</i> Veron et Wallace, 1984				+			
<i>Acropora squamata</i> Latypov, 1992		+			+		
<i>Acropora speciosa</i> (Quelch, 1886)				+			+
<i>Acropora subglabra</i> (Brook, 1891)		+					
<i>Acropora tenuis</i> (Dana, 1846)		+		+	+	+	+

Table (Continued)

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Acropora valenciennesi</i> (Edwards et Haime, 1860)	+	+		+	+	+	+
<i>Acropora valida</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Acropora vaughani</i> Wells, 1954	+		+		+	+	
<i>Alveopora allingi</i> Hoffmeister, 1925	+	+					+
<i>Alveopora marionensis</i> Veron et Pichon, 1982			+	+			
<i>Alveopora verrilliana</i> Dana, 1872			+				+
<i>Anacropora forbesi</i> Ridley, 1884				+			+
<i>Astreopora cuculata</i> Lamberts, 1980		+				+	
<i>Astreopora listeri</i> Bernard, 1896			+	+	+	+	+
<i>Astreopora longiseptata</i> Latypov, 2014			+				
<i>Astreopora myriophthalma</i> (Lamarck, 1816)	+	+	+	+	+	+	+
<i>Astreopora ocellata</i> Bernard, 1896	+	+	+	+	+	+	+
<i>Australogyra zelli</i> (Veron et Pichon, 1977)		+					
<i>Balanophyllia cummingii</i> (Edwards et Haime, 1848)	+	+					
<i>Balanophyllia stimpsoni</i> Verrill, 1865	+	+					
<i>Barabattoia amicorum</i> (Edwards et Haime, 1850)		+	+	+	+	+	+
<i>Barabattoia mirabilis</i> Yabe et Sugiyama, 1941	+	+		+	+	+	+
<i>Caulastrea furcata</i> Dana, 1846		+		+		+	
<i>Caulastrea tumida</i> Matthai, 1928		+	+	+			+
<i>Coeloseris mayeri</i> Vaughan, 1918		+	+				+
<i>Coscinaraea columna</i> (Dana, 1846)		+	+	+	+	+	+
<i>Coscinaraea exesa</i> (Dana, 1846)	+	+	+	+			
<i>Coscinaraea mcneilli</i> Wells, 1962		+	+				
<i>Ctenactis echinata</i> (Pallas, 1766)		+	+	+	+	+	+
<i>Cycloseris</i> cf. <i>sinensis</i> (Edwards et Haime, 1851)		+	+				+
<i>Cycloseris costulata</i> (Ortman, 1889)		+	+	+		+	+
<i>Cycloseris cyclolites</i> Lamarck, 1801		+	+	+		+	+
<i>Cycloseris densicolummelus</i> Latypov, 2006		+					
<i>Cycloseris patelliformis</i> (Boschma, 1923)		+	+				+

Table (Continued)

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Cycloseris somervillei</i> (Gardiner, 1909)						+	
<i>Cycloseris tenuis</i> (Dana, 1846)			+			+	+
<i>Cycloseris vaughani</i> (Boschma, 1923)			+			+	+
<i>Cynarina lacrymalis</i> (Edwards et Haime, 1848)				+			+
<i>Cyphastrea chalcidicum</i> (Forskål, 1775)	+	+	+				+
<i>Cyphastrea japonica</i> Yabe et Sugiyama, 1932	+	+		+			
<i>Cyphastrea microphthalma</i> (Lamarck, 1816)		+	+	+	+	+	+
<i>Cyphastrea serailia</i> (Forskål, 1775)	+	+	+	+	+	+	+
<i>Dendrophyllia aculeata</i> Latypov, 2014	+					+	
<i>Dendrophyllia arbuscula</i> Van der Horst, 1922	+		+			+	
<i>Dendrophyllia cornigera</i> (Lamarck, 1816)							+
<i>Dendrophyllia borstii</i> Gardiner et Vaughan, 1939	+		+			+	
<i>Dendrophyllia japonica</i> Regberg, 1892		+				+	
<i>Dendrophyllia laborelli</i> Zibrovius et Brilo, 1984	+						
<i>Dendrophyllia robusta</i> (Bourne, 1905)				+			+
<i>Dendrophyllia sphaerica</i> Nemenzo, 1981	+	+					
<i>Diaseris fragilis</i> Alcock, 1893		+	+	+			+
<i>Diploastrea heliopora</i> (Lamarck, 1816)	+	+	+	+	+	+	+
<i>Echinophyllia aspera</i> (Ellis et Solander, 1786)	+	+	+	+			+
<i>Echinophyllia echinata</i> (Saville-Kent, 1975)	+	+	+			+	
<i>Echinophyllia echinoporoides</i> Veron et Pichon, 1980		+	+	+	+	+	+
<i>Echinophyllia nichitirai</i> Veron et Pichon, 1990		+		+			+
<i>Echinophyllia orpheensis</i> Veron et Pichon, 1979	+	+	+	+	+	+	+
<i>Echinophyllia patula</i> (Hodgson et Ross, 1981)				+			
<i>Echinophyllia gemmacea</i> (Lamarck, 1816)				+			
<i>Echinopora hirsutissima</i> Edwards et Haime, 1849	+	+	+	+		+	+
<i>Echinopora horrida</i> Dana, 1846				+		+	
<i>Euphyllia ancora</i> Veron et Pichon, 1980			+	+		+	+
<i>Euphyllia cristata</i> Chevalier, 1971				+		+	

Table (Continued)

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Euphyllia divisa</i> Veron et Pichon, 1980				+	+	+	+
<i>Euphyllia glabrescens</i> (Chamisso et Eysenhard, 1821)	+	+	+	+	+	+	+
<i>Euphyllia grandiseptata</i> Latypov, 2014				+			
<i>Euphyllia yaeyamaensis</i> (Shirai, 1980)			+	+			+
<i>Favia foveus</i> (Forskål, 1775)	+	+		+		+	+
<i>Favia laxa</i> (Klunzinger, 1879)	+	+		+			
<i>Favia lizardensis</i> Veron et Pichon, 1977	+	+	+	+	+	+	+
<i>Favia maritima</i> (Nemanzo, 1971)	+	+	+	+	+	+	+
<i>Favia matthai</i> Vaughan, 1918	+	+		+	+	+	+
<i>Favia maxima</i> Veron et al., 1977	+	+		+	+	+	+
<i>Favia pallida</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Favia rotumana</i> (Gardiner, 1889)	+	+	+	+	+	+	+
<i>Favia rotundata</i> (Veron et Pichon, 1977)		+			+	+	
<i>Favia speciosa</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Favia stelligera</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Favia truncatus</i> Veron, 2000		+					
<i>Favia veroni</i> Moll et Best, 1984		+		+			
<i>Favites abdita</i> (Ellis et Solander, 1786)	+	+	+	+	+	+	+
<i>Favites chinensis</i> (Verrill, 1866)	+	+	+	+			
<i>Favites complanata</i> (Ehrenberg, 1834)	+	+	+	+			
<i>Favites flexuosa</i> (Dana, 1846)	+	+	+	+			
<i>Favites halicora</i> (Ehrenberg, 1834)	+	+	+	+			
<i>Favites pentagona</i> (Esper, 1794)					+		+
<i>Favites russelli</i> (Wells, 1954)	+	+	+				
<i>Favites solidocolumellae</i> Latypov, 2014				+			
<i>Favites virens</i> (Dana, 1846)						+	+
<i>Fungia concinna</i> Verrill, 1864		+		+		+	
<i>Fungia corona</i> Döderlein, 1901		+					
<i>Fungia danai</i> Edwards et Haime, 1851	+	+	+	+		+	+

Table (Continued)

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Fungia fungites</i> (Linnaeus, 1758)	+	+	+	+	+	+	+
<i>Fungia granulosa</i> Klunzinger, 1879	+	+				+	
<i>Fungia horrida</i> Dana, 1846		+					+
<i>Fungia repanda</i> Dana, 1846		+		+		+	+
<i>Fungia scabra</i> Döderlein, 1901			+			+	
<i>Fungia scruposa</i> Klunzinger, 1879		+					+
<i>Fungia scutaria</i> Lamarck, 1801		+	+	+	+	+	+
<i>Fungia seychelensis</i> Hoeksema, 1993				+			
<i>Fungia valida</i> Verrill, 1864	+						+
<i>Galaxea astreata</i> (Lamarck, 1816)	+	+	+	+	+	+	+
<i>Galaxea crassiseptata</i> Latypov, 1998				+			
<i>Galaxea fascicularis</i> (Linnaeus, 1767)	+	+	+	+	+	+	+
<i>Galaxea vesiculosa</i> Latypov, 2014		+					
<i>Gardineroseris pavonoides</i> Latypov, 2014				+			
<i>Gardineroseris planulata</i> (Dana, 1846)		+	+	+		+	
<i>Goniastrea aspera</i> Verrill, 1865	+	+	+	+	+	+	+
<i>Goniastrea australiensis</i> (Edwards et Haime, 1857)		+		+		+	
<i>Goniastrea cf. palauensis</i> (Yabe et al., 1936)				+		+	
<i>Goniastrea edwardsi</i> Chevalier, 1971		+	+	+	+	+	+
<i>Goniastrea favulus</i> (Dana, 1846)				+		+	
<i>Goniastrea pectinata</i> (Ehrenberg, 1834)	+	+	+	+	+	+	+
<i>Goniastrea retiformis</i> (Lamarck, 1816)	+	+	+	+	+	+	+
<i>Goniopora columna</i> Dana, 1846	+	+	+		+		+
<i>Goniopora djiboutiensis</i> Vaughan, 1907		+					
<i>Goniopora fruticosa</i> Saville-Kent, 1893			+				+
<i>Goniopora lobata</i> Edwards et Haime, 1851	+	+	+	+	+	+	+
<i>Goniopora pandoraensis</i> Veron et Pichon, 1982		+	+				
<i>Goniopora stokesi</i> Edwards et Haime, 1851	+	+	+	+	+	+	+
<i>Goniopora stutchburyi</i> Wells, 1955	+	+	+				

Table (Continued)

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Goniopora tenuidens</i> Quelch, 1886	+	+	+				+
<i>Halomitra pileus</i> (Linnaeus, 1758)	+						+
<i>Heliofungia actiniformis</i> (Quoy et Gaimard, 1833)				+			
<i>Herpolitha limax</i> (Esper, 1797)	+	+	+	+	+	+	+
<i>Herpolitha weberi</i> (Van der Horst, 1921)		+	+				+
<i>Heterocyathis aequicostatus</i> Edwards et Haime, 1848		+					
<i>Heteropsammia cochlea</i> (Spengler, 1781)		+					+
<i>Hydnophora exesa</i> (Pallas, 1766)	+	+	+	+	+	+	+
<i>Hydnophora microconos</i> (Lamarck, 1816)	+	+	+	+	+	+	+
<i>Hydnophora rigida</i> (Dana, 1846)			+	+	+	+	+
<i>Isopora cuneata</i> Dana, 1846		+	+	+	+	+	+
<i>Isopora palifera</i> (Lamarck, 1816)		+	+	+	+	+	+
<i>Leptastrea bottae</i> (Edwards et Haime, 1849)	+	+					
<i>Leptastrea pruinosa</i> Crossland, 1952	+	+	+	+		+	
<i>Leptastrea purpurea</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Leptastrea transversa</i> Klunzinger, 1879	+	+	+	+	+		
<i>Leptoria phrygia</i> (Ellis et Solander, 1786)	+	+	+	+	+	+	+
<i>Leptoseris explanata</i> Yabe et Sugiyama, 1941		+	+	+		+	+
<i>Leptoseris gardineri</i> Van der Horst, 1921		+				+	
<i>Leptoseris hawaiiensis</i> Vaughan, 1907	+	+					
<i>Leptoseris mycetoseroides</i> Wells, 1954	+	+	+	+			+
<i>Leptoseris scaba</i> Vaughan, 1907		+		+			
<i>Leptoseris var. mycetoseroides</i> Wells, 1954		+		+			
<i>Leptoseris yabei</i> (Pillai et Scheer, 1976)	+	+	+	+		+	+
<i>Lithophyllon bistomatum</i> Latypov, 1995		+					
<i>Lithophyllon mokai</i> Hoeksema, 1989	+	+		+			+
<i>Lithophyllon undulatum</i> Rehberg, 1892	+	+	+	+	+		+
<i>Lobophyllia grandis</i> Latypov, 2014	+	+		+			
<i>Lobophyllia corymbosa</i> (Foskäl, 1775)	+	+	+	+			+

Table (Continued)

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Lobophyllia flabellioformis</i> Veron, 2000				+			
<i>Lobophyllia hattai</i> Yabe, Sygiyama et Eguchi, 1936	+	+	+	+	+	+	+
<i>Lobophyllia hemprichii</i> (Ehrenberg, 1834)	+	+	+	+	+	+	+
<i>Lobophyllia pachysepta</i> Chevalier, 1975		+	+	+			+
<i>Lobophyllia robusta</i> Yabe et Sugiyama, 1936	+			+			
<i>Madracis kirbyi</i> Veron et Pichon, 1976	+	+	+	+	+	+	
<i>Merulina ampliata</i> (Ellis et Solander, 1786)	+	+	+	+	+	+	+
<i>Merulina scabriscula</i> Dana, 1846					+		
<i>Montastrea annuligera</i> (Edwards et Haime, 1849)	+	+	+	+		+	+
<i>Montastrea colemani</i> Veron, 2000				+			
<i>Montastrea curta</i> (Dana, 1846)	+	+	+	+		+	+
<i>Montastrea magnistellata</i> Chevalier, 1971	+						
<i>Montastrea valenciennesi</i> (Edwards et Haime, 1848)	+	+	+	+		+	+
<i>Montipora aequituberculata</i> Bernard, 1897	+	+	+	+	+	+	+
<i>Montipora angulata</i> (Lamarck, 1816)			+	+		+	
<i>Montipora australiensis</i> Bernard, 1897	+	+				+	+
<i>Montipora caliculata</i> (Dana, 1846)	+	+		+		+	+
<i>Montipora crassituberculata</i> Bernard, 1897			+	+	+	+	+
<i>Montipora danae</i> Edwards et Haime, 1851	+		+	+		+	
<i>Montipora digitata</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Montipora efflorescens</i> Bernard, 1897		+					+
<i>Montipora foliosa</i> (Pallas, 1766)		+		+			+
<i>Montipora grisea</i> Bernard, 1897		+		+	+		+
<i>Montipora hispida</i> (Dana, 1846)		+		+	+	+	+
<i>Montipora boffmeisteri</i> Wells, 1954	+	+	+	+		+	
<i>Montipora informis</i> Bernard, 1897		+	+			+	
<i>Montipora millepora</i> Crossland, 1952		+	+		+		+
<i>Montipora molis</i> Bernard, 1897			+	+		+	
<i>Montipora monasteriata</i> (Forskål, 1775)	+		+				+

Table (Continued)

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Montipora nodosa</i> (Dana, 1846)	+	+	+	+			+
<i>Montipora porites</i> Veron, 2000			+				
<i>Montipora spongodes</i> Bernard, 1897	+	+	+	+		+	+
<i>Montipora spumosa</i> (Lamarck, 1816)	+	+					+
<i>Montipora stellata</i> Bernard, 1897		+	+				
<i>Montipora tuberculosa</i> (Lamarck, 1816)	+	+	+	+	+	+	+
<i>Montipora turgescens</i> Bernard, 1897	+	+	+	+	+	+	+
<i>Montipora turtlensis</i> Veron et Wallace, 1984							
<i>Montipora undata</i> Bernard, 1897	+	+	+	+		+	+
<i>Montipora venosa</i> (Ehrenberg, 1834)	+	+			+	+	
<i>Montipora verrucosa</i> (Lamarck, 1816)		+	+	+	+	+	+
<i>Montipora vietnamensis</i> Veron, 2000				+			
<i>Moseleya latistellata</i> Quelch, 1884		+					+
<i>Mycedium elephantiotus</i> (Pallas, 1766)	+		+	+	+	+	+
<i>Oulastrea alta</i> Nemenzo, 1981		+					
<i>Oulastrea crispata</i> (Lamarck, 1816)	+	+	+	+	+	+	+
<i>Oulophyllia bennettiae</i> (Veron et Pichon, 1977)		+	+	+	+	+	+
<i>Oulophyllia crispa</i> (Lamarck, 1816)	+	+	+	+	+	+	+
<i>Oulophyllia levis</i> (Nemenzo, 1959)			+	+			+
<i>Oxypora glabra</i> Nemenzo, 1959				+			+
<i>Oxypora lacera</i> (Verrill, 1864)	+	+		+		+	+
<i>Pachyseris rugosa</i> (Lamarck, 1801)	+	+	+	+	+	+	+
<i>Pachyseris speciosa</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Pachyseris monticulosa</i> Latypov, 2014				+		+	+
<i>Palauastrea ramosa</i> Yabe et Sugiyama, 1941							
<i>Parona cactus</i> (Forskål, 1775)	+	+		+		+	+
<i>Parona clavus</i> (Dana, 1846)	+	+		+	+	+	+
<i>Parona decussata</i> (Dana, 1846)	+	+		+	+	+	+
<i>Parona distincta</i> Latypov, 2014							

Table (Continued)

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Pavona explanulata</i> (Lamarck, 1816)		+	+	+	+	+	+
<i>Pavona frondifera</i> (Lamarck, 1801)		+		+			+
<i>Pavona maldivensis</i> (Gardiner, 1905)		+		+			+
<i>Pavona minuta</i> Wells, 1954		+	+				+
<i>Pavona varians</i> Verrill, 1864		+	+	+			+
<i>Pavona venosa</i> (Ehrenberg, 1834)		+				+	
<i>Pectinia alcorni</i> (Saville-Kent, 1871)	+			+	+	+	+
<i>Pectinia lactuca</i> (Pallas, 1766)	+	+	+	+	+	+	+
<i>Pectinia paeonia</i> (Dana, 1846)	+	+		+	+	+	+
<i>Physogyra lichtensteini</i> (Edwards et Haime, 1851)		+	+	+	+	+	+
<i>Platygyra daedalia</i> (Ellis et Solander, 1786)	+	+	+	+	+	+	+
<i>Platygyra lamellina</i> (Ehrenberg, 1834)	+	+	+	+	+	+	+
<i>Platygyra pini</i> Chevalier, 1975	+	+		+	+	+	+
<i>Platygyra sinensis</i> (Edwards et Haime, 1849)	+	+	+	+	+		
<i>Plerogyra sinuosa</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Plesiastrea versipora</i> (Lamarck, 1816)	+	+	+	+	+	+	+
<i>Pleuractis moluccensis</i> Van der Horst, 1919		+				+	
<i>Pleuractis paumotensis</i> (Stuthbury, 1833)		+		+	+		+
<i>Pocillopora capitata</i> Verrill, 1864				+			
<i>Pocillopora damicornis</i> (Linnaeus, 1758)	+	+	+	+	+	+	+
<i>Pocillopora eydouxi</i> Edwards et Haime, 1860		+	+	+	+	+	+
<i>Pocillopora kelleheri</i> Veron, 2000				+			
<i>Pocillopora meandrina</i> Dana, 1846		+	+	+		+	
<i>Pocillopora verrucosa</i> (Ellis et Solander, 1786)	+	+	+	+	+	+	+
<i>Pocillopora woodjonesi</i> Vaughan, 1918		+	+	+	+	+	+
<i>Podabacia crustacea</i> (Pallas, 1766)	+	+	+	+	+	+	+
<i>Polyphyllia novaehiberniae</i> (Lesson, 1831)						+	
<i>Polyphyllia talpina</i> (Lamarck, 1831)	+	+	+	+	+	+	+
<i>Portites annae</i> Crossland, 1952			+	+	+		+

Table (Continued)

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Porites attenuata</i> Nemenzo, 1955				+		+	+
<i>Porites australiensis</i> Vaughan, 1918	+	+	+	+	+	+	+
<i>Porites cylindrica</i> Dana, 1846		+	+	+	+	+	+
<i>Porites deformis</i> Nemenzo, 1955				+			+
<i>Porites densa</i> Vaughan, 1918	+	+					
<i>Porites lichen</i> Dana, 1846	+	+	+	+	+	+	+
<i>Porites lobata</i> Dana, 1846	+	+	+	+	+	+	+
<i>Porites lutea</i> Edwards et Haime, 1860	+	+	+	+	+	+	+
<i>Porites mayeri</i> Vaughan, 1918	+	+	+	+	+	+	+
<i>Porites monticulosa</i> Dana, 1846				+			+
<i>Porites mordax</i> Dana, 1846	+	+					+
<i>Porites murrayensis</i> Vaughan, 1918	+	+	+	+	+		+
<i>Porites nigrescens</i> Dana, 1848		+	+	+	+	+	+
<i>Porites rus</i> (Forskål, 1775)	+	+	+	+	+	+	+
<i>Porites solida</i> (Forskål, 1775)	+	+	+	+	+		
<i>Porites</i> sp. 1			+				
<i>Porites</i> sp. 2	+	+	+	+	+		
<i>Porites stephensoni</i> Crossland, 1952	+	+	+	+	+		
<i>Porites vaughani</i> Crossland, 1952			+	+	+		+
<i>Psammocora configua</i> (Esper, 1797)	+	+	+	+	+	+	+
<i>Psammocora digitata</i> Edwards et Haime, 1851				+	+	+	+
<i>Psammocora explanulata</i> Van der Horst, 1922		+	+				
<i>Psammocora nierstraszi</i> Van der Horst, 1921	+	+	+	+	+	+	+
<i>Psammocora profundacella</i> Gardiner, 1898	+	+	+	+		+	
<i>Psammocora superficialis</i> Gardiner, 1898	+	+	+			+	+
<i>Pseudosiderastrea tayamai</i> Yabe et Sugiyama, 1935	+	+	+	+	+	+	+
<i>Sandalolitha dentata</i> Quelch, 1884	+	+	+	+	+	+	+
<i>Sandalolitha robusta</i> (Quelch, 1886)	+	+	+	+	+	+	+
<i>Scolymia</i> aff. <i>vitiensis</i> Brüggemann, 1877		+	+	+	+	+	

Table (Continued)

Species	Gulf of Tonkin	Gulf of Siam	Central Vietnam	Nha Trang Bay	Thu Island	Con Dao Islands	Spratly Archipelago
<i>Scolymia australis</i> (Edwards et Haime, 1849)		+		+	+	+	+
<i>Seriatopora calidrum</i> Ehrenberg, 1834		+					
<i>Seriatopora bystrix</i> Dana, 1846		+	+	+	+	+	+
<i>Sylocoeniella guentheri</i> (Basset-Smith, 1890)	+						
<i>Stylophora pistillata</i> (Esper, 1797)	+	+	+	+	+	+	+
<i>Stylophora subseriata</i> (Ehrenberg, 1834)		+					
<i>Symphylia agaricia</i> Edwards et Haime, 1849	+	+		+	+	+	+
<i>Symphylia erythraea</i> (Klunzinger, 1879)				+			
<i>Symphylia bassi</i> Pillai et Scheer, 1976	+	+					
<i>Symphylia radians</i> Edwards et Haime, 1849	+	+	+	+	+	+	+
<i>Symphylia recta</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Symphylia valenciennesii</i> Edwards et Haime, 1849	+	+	+	+	+	+	+
<i>Trachyphyllia geoffroyi</i> (Audouin, 1826)				+	+	+	+
<i>Tubastrea aurea</i> (Quoy et Gaimard, 1833)	+	+	+	+	+	+	+
<i>Tubastrea coccinea</i> (Ehrenberg, 1834)	+	+		+	+	+	+
<i>Tubastrea diaphana</i> (Dana, 1846)				+	+	+	
<i>Tubastrea micrantha</i> (Ehrenberg, 1834)	+	+	+	+	+	+	+
<i>Turbinaria bifrons</i> Brüggemann, 1877	+	+	+	+	+	+	
<i>Turbinaria conspicua</i> Bernard, 1896		+	+				+
<i>Turbinaria contorta</i> Bernard, 1896		+		+			
<i>Turbinaria crater</i> (Pallas, 1766)	+	+					+
<i>Turbinaria frondens</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Turbinaria mesenterina</i> (Dana, 1846)	+	+	+	+	+	+	+
<i>Turbinaria patula</i> (Dana, 1846)		+	+	+			
<i>Turbinaria peltata</i> (Esper, 1794)	+	+	+	+	+	+	+
<i>Turbinaria radialis</i> Bernard, 1896	+	+		+			+
<i>Turbinaria reniformis</i> Bernard, 1896	+	+	+	+	+	+	+
<i>Turbinaria stellata</i> (Lamarck, 1816)		+				+	

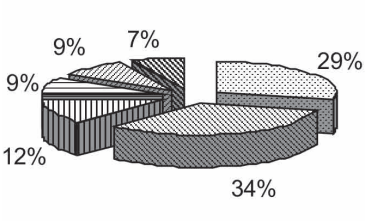


Fig. 3. Relative diversity of major coral families in Vietnam. 1 – Acroporidae, 2 – Faviidae, 3 – Fungiidae, 4 – Poritidae, 5 – Dendrophillidae, 6 – other families.

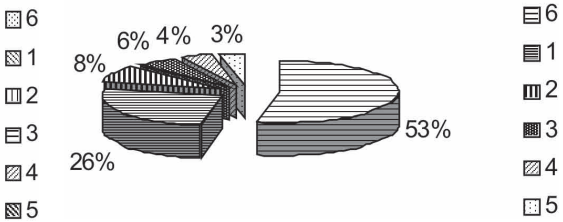


Fig. 4. Relative diversity of major coral genera in Vietnam. 1 – *Acropora*, 2 – *Montipora*, 3 – *Porites*, 4 – *Favia*, 5 – *Fungia*, 6 – other genera.



Fig. 5. Monospecific settlement on the reef. Myeu Island, Nha Trang Bay, depth 2 m.

Reef communities in both gulfs lack members of *Palauastrea* and *Caulastrea* and *Acropora cuneata*, the latter occurring in most Vietnam reefs. *Plerogyra* and *Physogyra* are absent from the closed part of the Gulf of Tonkin, and *Pachyseris*, *Mycedium*, and *Pectinia*, from the Gulf of Siam and adjacent coastal areas. However, some

members of the latter three genera and rare *Physogyra* and *Plerogyra* species are found in the open parts of both gulfs, off Hainan and Tho Chu islands. Corals having large polyp forms and capable of self cleaning – *Galaxea*, *Echinopora*, *Lobophyllia*, *Echinophyllia*, *Turbinaria*, *Podobacia*, *Lithophyllon*, *Fungia*, and *Goniopora* are widespread in both gulfs. The reefs in both gulfs are dominated by many species of these genera (*Galaxea fascicularis* (L., 1767), *Goniopora stokesi* Edwards et Haime, 1851, and *Lobophyllia hemprichii* (Ehrenberg, 1834)), as well as by *Acropora cytherea* (Dana, 1846),

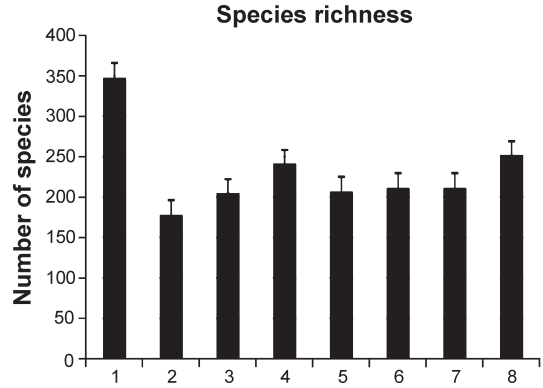


Fig. 6. The species richness of scleractinian species in different regions of Vietnam. 1 – total number of species (347), 2 – Gulf of Tonkin (177), 3 – Central Vietnam (204), 4 – South Vietnam (240), 5 – Thu Island (206), 6 – Con Dao Islands (210), 7 – Spratly Island (211), 8 – Gulf of Siam (251).



Fig. 7. The richest coral settlement on the optimal Vietnam reef, Re Island, depth 9 m.

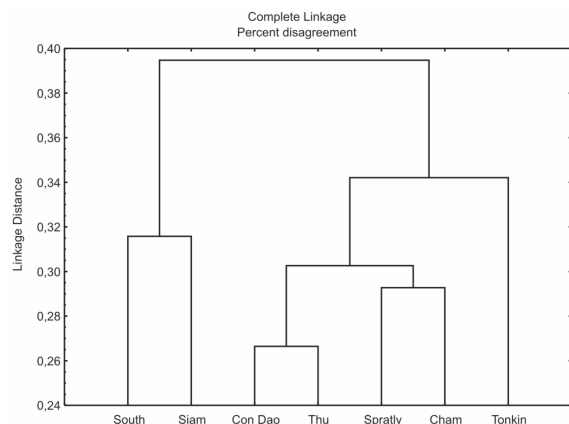


Fig. 8. Dendrogram showing the similarity of species composition of corals in different regions of Vietnam.

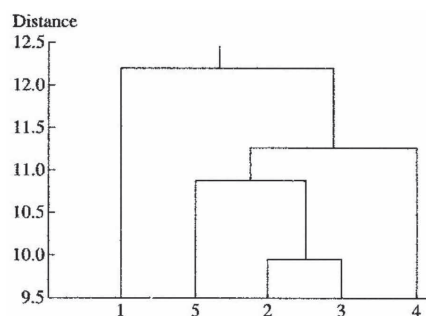


Fig. 9. Similarity dendrogram of scleractinian faunas in different regions of Vietnam. 1 – Gulf of Tonkin, 2 – Central Vietnam, 3 – Southern Vietnam, 4 – Gulf of Siam, 5 – Spratly Island.

A. nobilis (Dana, 1846), *Montipora hispida* (Dana, 1846), *Porites lobata* Dana, 1846, and *P. cylindrica* Dana, 1846, widespread in Indo-Pacific reefs. Altogether, these species cover 60–80% of the substrate. Massive *Porites* colonies (at least, 10 species) forming vast monospecific settlements are typical of both gulfs. At the same time, members of *Pocillopora*, abundant in most Indo-Pacific reefs (5–7 species), only rarely occur in the innermost parts of the gulfs (2 species maximum) but are common for island reefs in the open parts of the gulfs (Tho Chu, Hainan). The two gulfs are quite similar in coral diversity and share 74.3% of species.

Benthic communities are rather uniformly distributed over the coastal waters of Vietnam and have similar characteristic properties (Fig. 2). As a rule, these are algal-coral communities, composed of several communities (zones, facies), and dominated by individual algal or coral species or by groups of species (Fig. 10). The predominance of *Laurencia*, *Turbinaria*, and *Sargassum* algae in the coastal zones of the reefs has been reported for many reef development areas. This may be indicative of an increase in water eutrophication or later stages of reef development (Mergner, 1979; Dollar, 1982; Dai, 1993; Latypov, 1999).

Both along the Vietnam coast and in the whole Indo-Pacific, in reef zones characterized by relatively stable conditions (lagoons, deep stony and coral terraces, and reef slopes), branched, plate, and trumpet colonies of *Acropora cytherea* (Dana, 1846), *A. hyacinthus* (Dana, 1846), *Montipora danae* Edwards et Haime, 1851, *M. foliosa* (Pallas, 1766), *P. cylindrica*, and others successfully compete with differently shaped scleractinian colonies (Liddel, Ohlhorst, 1987; Latypov, 1988; Dai, 1993).

A wider distribution of encrusting and plate colonies of *Euphyllia*, *Echinophyllia*, *Mycedium*, *Pachyseris*, and *Turbinaria* compared to that of branched forms

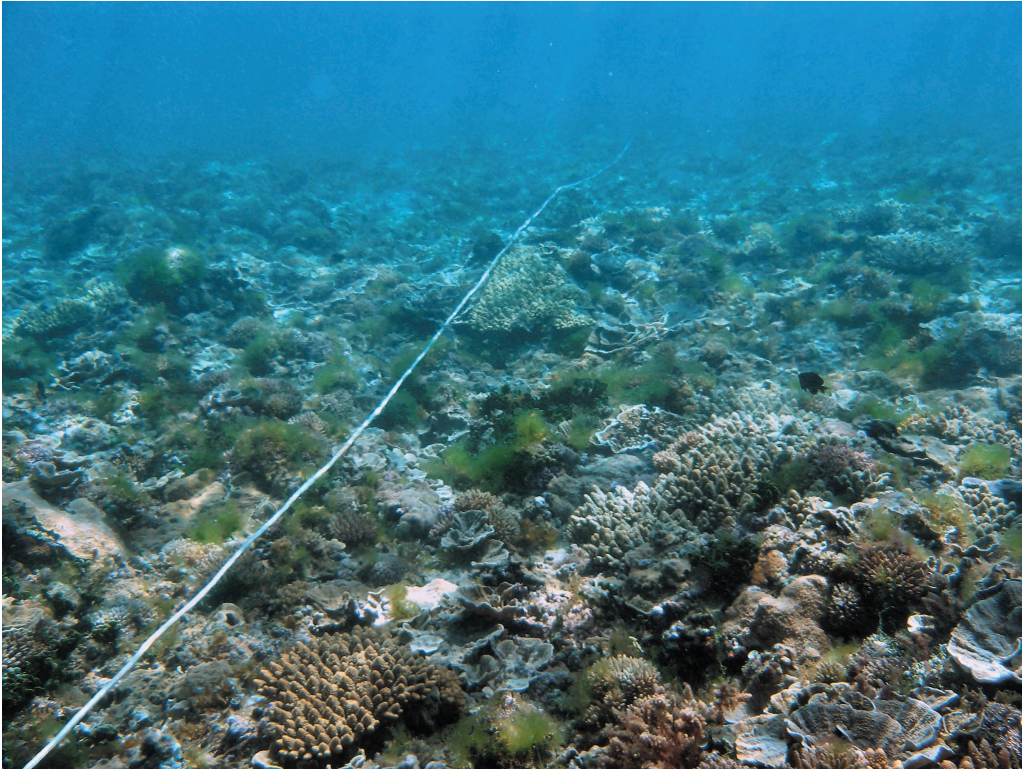


Fig. 10. Algal-coral community on Bathlongvi reef, depth 2 m.

is directly caused by lowered illumination (Fig. 11). This is also the case in many reefs of the Indo-Pacific and Caribbean basins (Loya, 1976b; Porter, 1976; Tomasik, Sander, 1987). In Vietnam's reefs, such corals are common for communities of the slope base, bioherms zone, and fore reef platform.

Caused by abiotic factors, the vertical distribution of reef-building corals has a strong effect on the development of biotic zonation across a whole reef community, beginning with settlement-site choice and ending with interspecific trophic relationships. The relationships between the species composition of benthic communities of some reefs as revealed by cluster analysis correlated with the ecological and physiographical zonation of the reefs (Fig. 12).

Algal-coral lagoon and reef flat communities dominated by red and brown algae and similar in coral and common macrobenthos species composition formed a single cluster group, that of communities developing under similar conditions. The high similarity between coral faunas from different sites reflected similar, sometimes extreme, conditions of reef flat and shallow-water stone terrace. At the same

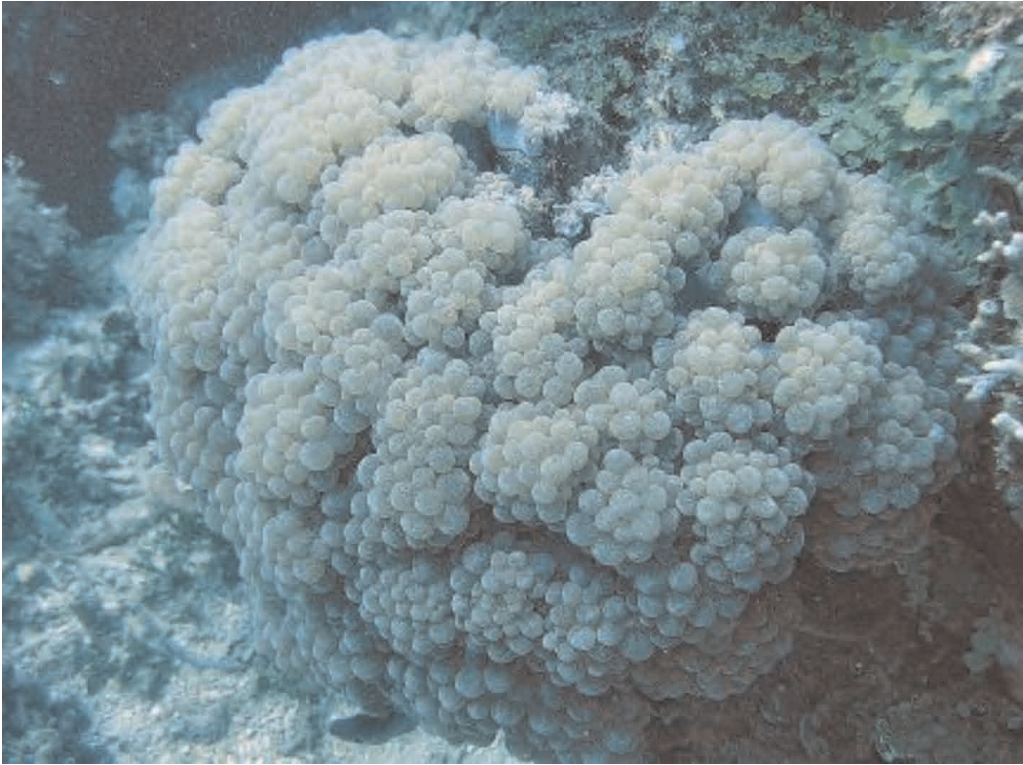
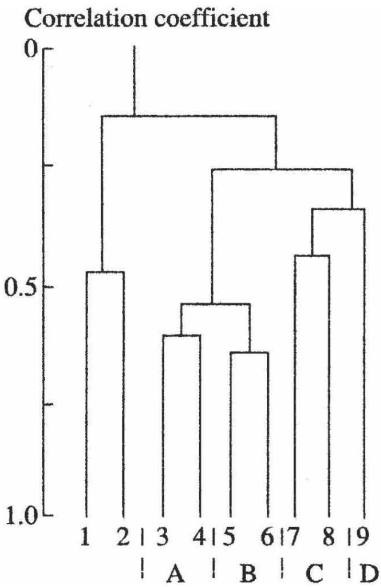


Fig. 11. Coral *Euphyllia yavayamaensis* in the twilight zone of the reef slope, depth 20 m.



time, communities of these reef zones were set apart from those of neighboring reef zones. Both in structural and unstructured reefs, reef slope communities sharing a relatively greater number of corals and having the highest level of similarity in their specific variability also formed a distinct cluster (Fig. 13).

Fig. 12. Cluster dendrogram of the species composition of benthic communities. Algal-coral community, unstructured (1) and structural (2) reefs; *Acropora* community, unstructured (3) and structural (4) reefs; *Acropora*+*Diploastrea* community, unstructured (5) and structural (6) reefs; (7) bioherm community (reef slope); (8) *Junceella*+*Diaseris* community; (9) *Malleus*+*Junceella* community. **A** – lagoon, **B** – reef flat and terrace zone, **C** – reef slope, **D** – for-reef platform.



Fig. 13. Coral community of a reef slope, Con Dao Island, depth 15 m.

To summarize the above, both structural and unstructured reefs feature vertical biological and geomorphological zonations. The latter is mainly determined by peculiarities of the underwater reef slope substrate. Similar biological zonation reflecting interzonal differences in environmental conditions (substrate, wave regime, sedimentation rate, illumination) has been reported for many Vietnam's reefs, as well as for various Pacific and Caribbean reefs (Dollar, 1982; Latypov, 1986; Sakai et al., 1986; Dai, 1993).

Shallow-water reefs of Vietnam growing in highly eutrophic conditions lack thick reef deposits (Latypov, 1986, 1995) and feature high coral diversity and distinct biological zonation, that is, the presence of inner heterotrophic (lagoon, reef flat) and outer autotrophic (reef slope) zones (Preobrazhensky, 1982; Sorokin, 1990; Latypov, 1994), which is characteristic of typical Indo-Pacific reefs.

In reefs of Indonesia and Philippines and in the Great Barrier Reef, a total of 360–410 reef-building scleractinians pertaining to 70–80 genera have been recorded (Veron, 1995). This region of the Western Pacific is considered the center of origin of tropical coral faunas. The maximum coral diversity is observed in the so-called Coral Triangle (Ekman, 1953; Stehli, Wells, 1971; Veron, 1995) with apices in the Philippines, the Malacca Peninsula, and New Guinea (Fig. 14).

The scleractinian fauna of Vietnam coast totals 376 species belonging to 80 genera. Moreover, Vietnam's reefs display high similarity in coral species composition to reefs of Thailand, Indonesia, and the Philippines (76.4, 72.3, and 81.6%, respectively). Therefore, Vietnam's reefs, obviously belong to the above-mentioned fertile center, too. In the greater Western Pacific Coral Triangle (with apices in Vietnam, South Japan, and the Great Barrier Reef), coral faunas are also highly similar and homogenous. The similarities between the Vietnam coral fauna and those of Japan and Australia are 77.5 and 86%, respectively, suggesting homogeneity of the coral fauna of the Western and Southwest Pacific. As a whole, the species complex of Vietnam scleractinians, as well as those of alcyonarians and gorgonarians, belongs to the tropical fauna, as the majority of Vietnam corals are also common for the equatorial Indo-Pacific reef zone. The scleractinian species composition of this area exceeds 80% of that of the Pacific, and the alcyonarian diversity of Vietnam's reefs is one of the greatest in the Indo-Pacific (Malyutin, Latypov, 1991; Latypov, 1995; Latypov, Long, 2010).

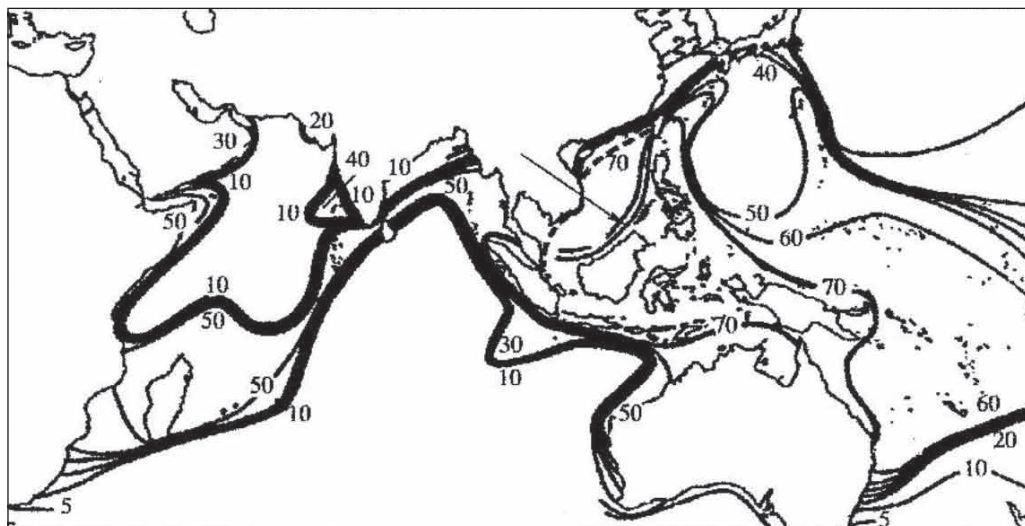


Fig. 14. Schematized map of the generic diversity of reef-building corals in different regions of the Indo-Pacific (after Veron, 1995, with modifications). The dotted line and arrow indicate new and old 70 genera diversity isolines, respectively.



Fig. 15. Optimal coral reef in Vietnam.

The species composition and high diversity of Vietnam's coral fauna, as well as its close similarity to the Southwest Pacific coral fauna, allow one to refer it to the Indonesia-Polynesian center of origin of the coral faunas of the tropical Indo-Pacific (Fig. 15). The entire Vietnam coast, from the Gulf of Tonkin to the Gulf of Siam, is a biogeographically single whole and is a part of the Indo-Polynesian Province of the Indo-Pacific Area.

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The species composition and distribution of macrobenthic communities in the intertidal zone of Vietnam

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Abstract: The species composition and vertical distribution of macrobenthic intertidal communities of Vietnam are described in various locations from the Gulf of Thailand in the south to the Gulf of Tonkin in the north. The intertidal biota is described in connection with environmental factors, such as features of substrata and wave action, influence of decrease in sea water salinity and also specific factors (tide pools, terrestrial vegetation). The macrobenthos of hard substrata is the richest in qualitative and quantitative composition, and the population of soft substrata is the poorest. The intertidal zone of dead coral reefs has no analogues in the boreal waters. At least, 1664 species, subspecies or varieties of macrobenthos (278 species of plants and 1386 species of animals) are found in the intertidal zone of Vietnam. Red algae dominate among plants (154 species), and gastropods (334 species) and decapods (275 species) prevail among animals. The paper uses both published and unpublished results of the investigations carried out in the intertidal zone of Vietnam from the 1950s to 2005.

Key words: macrobenthos, species composition, distribution, community, intertidal zone, Vietnam.

The intertidal zone is the area between the high and low tide marks. The boundary position between the two main habitats of life (air and water) is a unique feature of the intertidal zone, also defined as the amphibiotic zone. Organisms that live in this zone experience daily and seasonal fluctuations of temperature and changes in salinity and moisture and they must be able to tolerate extreme environmental changes.

The intertidal zone, being a more accessible zone of the sea, has traditionally played a key role in the life of marine organisms inhabiting the Indo-Pacific region. Many intertidal mollusks, crustaceans, echinoderms, and algae are edible; fossil corals are used for building, and sea shells for making various ornaments and souvenirs. Intertidal zone population is one of important objects of marine ecological/environmental studies.

The first information on the belt-forming communities was obtained in the 1950s for the intertidal zone of Cap Saint-Jacques (at present, Vung Tau) on the southern coast of Vietnam by P.-H. Fischer (Fischer, 1952). Later on, a detailed study was conducted of the intertidal zone of mainly rocky reefs in Nha Trang Bay by Tran-ngoc Loi (Tran-ngoc Loi, 1967) and Pham-Hoang Ho (Pham-Hoang Ho, 1958a, b, 1962–1963, 1964). But Pham-Hoang Ho studied mainly phyto-cenoses, and his publications are in details analyzed by Tran-ngoc Loi. In 1961 a Soviet-Vietnamese expedition under the leadership and with participation of E.F. Gurjanova studied the intertidal zone of the Gulf of Tonkin (Gurjanova, Chang Hiu Phuong, 1972). Several Soviet-Vietnamese expeditions over the seashore and coastal waters were undertaken in 1980–1984 (southern Vietnam), including the trip of the R/V *Akademik Alexander Nesmeyanov* in 1984 to Nam Du Archipelago and Thu Island, and in 1988 (along the entire coast of Vietnam, R/V *Professor Bogorov*) by the Institute of Marine Biology, Far East Science Center, the USSR Academy of Science (at present, A.V. Zhirmunsky Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences) and the Institute of Marine Research of the National Science Center of the Socialist Republic of Vietnam (at present, Institute of Oceanography, Vietnam Academy of Science and Technology). The results of these expeditions were published in several papers (Gulbin et al., 1987(1988); Gulbin et al., 1988; Kussakin et al., 1988; Nguyen Van Chung et al., 1988; Kostina et al., 1990, 1992; Gulbin, Kussakin, 1991; Kostina, Vasina, 1991; Kostina, 2008, 2010a, b, 2011b). In 2005 intertidal investigations were conducted during the trip of the R/V *Akademik Oparin* in Nha Trang and Van Phong bays. The present work summarizes the results of intertidal studies carried out in Vietnam from the 1950s to 2005, and based on the own data and the data from publications, most of which were written by the authors of the present work.

Materials and methods

The investigations, both our own and those described in the literature, were conducted on the continental coast and islands of Vietnam from the Nam Du Archipelago (9°40'57.5" N, 104°21'10.8" E), situated in the Gulf of Thailand, to Co To Island (20°58'01.6" N, 107°45'45.0" E), situated in the Gulf of Tonkin (Fig. 1; Table 1).

Sampling was commonly carried out at low tides; sometimes, however, samples had to be collected at high equatorial tides. Belt transects (perpendicularly to the coastline) were used to estimate the distribution of intertidal communities. The coastline along each transect was divided into three subzones, namely the upper, middle and lower subzones. The subdivision of the intertidal zone was done according to the Vaillant's principle of vertical stratification in the intertidal

zone (Vaillant, 1891). The boundaries of the upper, middle, and lower subzones were determined as the highest tide mark, the mean high water level of equatorial tide and the mean low water level of equatorial tide, and the lowest possible tide mark respectively. Irregular semi-diurnal tides are characteristic of the Catwick Islands (highest tide 3.3 m); regular diurnal tides are characteristic of Thu Island and the north-western part of the Gulf of Tonkin (the highest tide on Thu Island is 2.6 m, 3.9 m on Danh Do La and Dao Trao islands, 3.3 m at the Van Uc Estuary, and 4 m on Cat Ba and Co To islands, and Be Bank); in some locations of the Bai Tu Long Archipelago the highest tides can reach 4.5 m; irregular diurnal tides are typical for Re and Cham islands, Gio Islet, Tien Sa Peninsula, and Nha Trang Bay (the highest tide is 2.4, 2.3, 3.4, 1.6, and 2.5 m respectively). The communities were distinguished by dominating (usually belt-forming) species of macrobenthos. The distribution of species in the intertidal communities was provisionally estimated by eye.

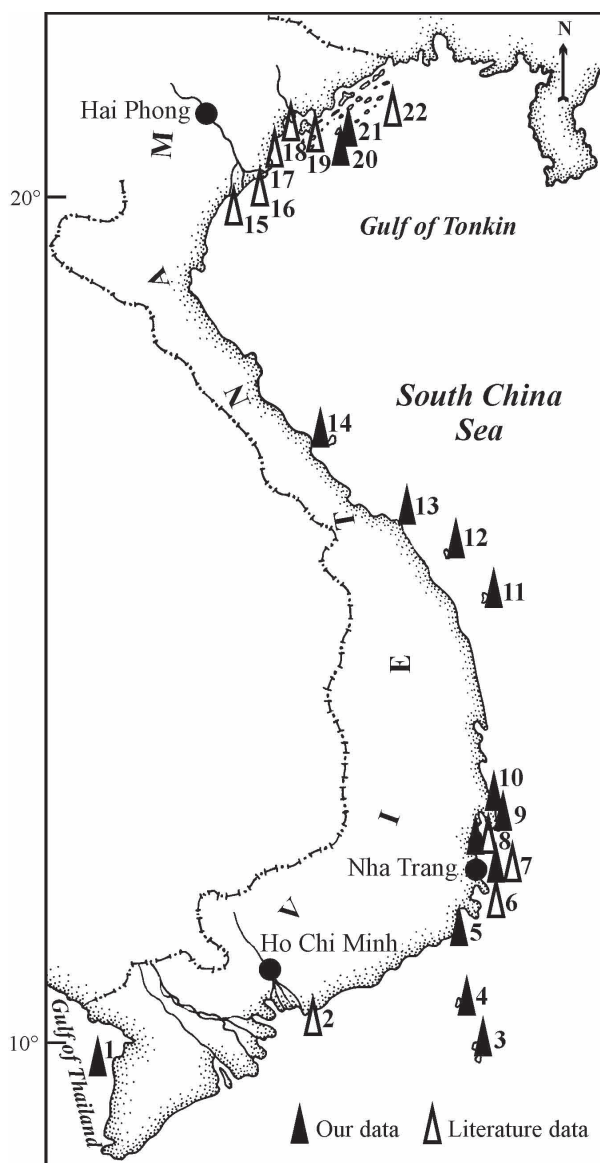


Fig. 1. A schematic map of the main studied locations in the intertidal zone of Vietnam. 1 – Nam Du Archipelago, 2 – Vung Tau, 3 – Catwick Islands, 4 – Thu Island, 5 – Cape Dinh, 6 – Pecheurs Islets, 7 – Nha Trang, 8 – Binh Cang Bay, 9 – Van Phong Bay, 10 – Ro Bay, 11 – Re Island, 12 – Cham Island, 13 – Tien Sa Peninsula, 14 – Gio Islet; the Red River Delta: 15 – Day Estuary, 16 – Ba Lat Estuary, 17 – Van Uc Estuary, 18 – Cam Estuary; 19 – Cat Ba Island, 20 – Danh Do La Island, 21 – Dao Trao Island, 22 – Co To Island. Detailed information about the sampling locations contains in Table 1.

Table 1

Sampling locations in the intertidal zone of Vietnam

Location	Latitude, N°	Longitude, E°	Substratum	References
Nam Du Archipelago, Gulf of Thailand				
Bo Tra (Bo Dap) Islet	9.647730	104.390174	Blocky-bouldery-gravelly	Gulbin et al., 1987(1988); our data, 1984
	9.659244	104.360375	Rocky	
	9.678994	104.346556	Boulders and pebble with underlying sand	
Nam Du Islet	9.691685	104.355107	Sandy	
	9.692721	104.355654	Boulders and small rocky blocks with underlying sand	
	9.704291	104.353938	Boulders and gravel with underlying sand, rare rocky blocks	
Mok (Moc) Islet	9.725308	104.354760	Rocky-blocky-bouldery	Kostina et al., 1992; our data, 1988
Gian (Tre) Islet	9.741729	104.364056	Bouldery-pebbly	
Catwick Islands				
Petite (Little) Catwick	9.995101	109.049789	Rocky	Kostina et al., 1992; our data, 1988
Grande Catwick	10.055923	108.897901	Rocky	
Cap Saint-Jacques (Vung Tau)	10.383333*	107.116667*	Rocky	Fischer, 1952
			Silted sand with admixture of breakstone	
Sud (Tranh) Islet	10.489852	108.963692	Sandy	Gulbin et al., 1987 (1988); our data, 1984

Table 1 (Continued)

Location	Latitude, N°	Longitude, E°	Substratum	References
Thu (Phu Quy) Island	10.509748	108.967619	Rocky-blocky-bouldery	Kostina et al., 1992; our data, 1988
	10.512238	108.966525	Rocky blocks with underlying sand	Gulbin et al., 1987 (1988); our data, 1984
	10.545865	108.955860	Rocky	
	10.552858	108.946215	Rocky blocks with underlying sand	
Cape Dinh (Padaran)	11.369978*	109.020036*	Rocky	Kussakin et al., 1988; Nguyen Van Chung et al., 1988; our data, 1981
Thon Son Hai	11.421749	109.012952	Dead coral reef	Tran-ngoc Loi, 1967
Noi Islet, Pecheurs Islets	12.045563*	109.327124*	Rocky	
Bau Than Bay	12.168081*	109.208148*	Dead coral reef Silted-sandy and sandy	
Mot Island	12.177447*	109.274349*	Rocky Bouldery	Kussakin et al., 1988; our data, 1980–1981
Tam Island	12.179919*	109.245292*	Boulders with underlying sand Old barges	
Mieu Island	12.185988	109.225815	Rocky-blocky-bouldery	
	12.190024*	109.226358*	Pebbly Boulders with underlying sand Rocky	Kussakin et al., 1988; Nguyen Van Chung et al., 1988; our data, 1980–1982
	12.194175*	109.234153*	Rocky	Tran-ngoc Loi, 1967

Table 1 (Continued)

Location	Latitude, N°	Longitude, E°	Substratum	References
Tre Island				
	12.190823*	109.288911*	Silted-sandy and sandy	Kussakin et al., 1988; our data, 1980–1981
	12.228662*	109.243808*	Boulders with underlying sand	
Dam Chinh Bay	12.193314	109.323928	Silted sand with admixture of shell and rare gravel	
Gieng Da (Me) Bay	12.224403*	109.238799*	Boulders with underlying sand	Tran-ngoc Loi, 1967
Cape Chut	12.208124*	109.216091*	Rocky	
Nha Trang Bay				
Than Islet (Rocher Noir)	12.235661*	109.233150*	Rocky	
Cape Hon Chong	12.272942*	109.206835*	Rocky	
Rua (Tortue) Islet	12.288892*	109.243641*	Dead coral reef Rocky	Kussakin et al., 1988; Nguyen Van Chung et al., 1988; our data, 1980–1982
Bai Tien Beach	12.302275*	109.240075*	Dead coral reef	
Cape Mong Ga (Khe Ga)	12.305395*	109.242221*	Rocky	Tran-ngoc Loi, 1967
Cai Sung Bay	12.374781	109.301679	Rocky	Kussakin et al., 1988; Nguyen Van Chung et al., 1988; our data, 1980–1982
Nha Phu Bay, Binh Cang Bay	12.377880	109.302132	Dead coral reef	
Thi Island	12.389468*	109.230409*	Dead coral reef Silted-sandy and sandy	
Trong (Giua) Islet	12.400253*	109.222988*	Silted-sandy and sandy	Kussakin et al., 1988; our data, 1980–1981

Table 1 (Continued)

Location	Latitude, N°	Longitude, E°	Substratum	References
Tan Thuy	12.435716*	109.164131*	Silted sand with admixture of shell, clay and mud, rocky blocks	Tran-ngoc Loi, 1967
	12.442757	109.169109	Silted sand with admixture of shell and rare gravel	Kussakin et al., 1988; Nguyen Van Chung et al., 1988; our data, 1980–1982
Van Phong Bay				
Cai Ban Bay	12.478428*	109.294956*	Boulders with underlying sand and admixture of coral debris	Our data, 1984
Lon Island	12.550318	109.407318	Rocky	Kussakin et al., 1988; Nguyen Van Chung et al., 1988; our data, 1980–1982
	12.627774	109.350529		
	12.551156	109.396224	Rocky blocks with underlying sand	Kussakin et al., 1988; our data, 1981 Our data, 2005
	12.563111	109.383915	Rocky-blocky-bouldery	
	12.6*	109.36667*	Pebbly	Kussakin et al., 1988; Nguyen Van Chung et al., 1988; our data, 1980–1982
			Dead coral reef	
Tre Bay	12.599590	109.339739	Boulders and pebble with underlying sand	Kussakin et al., 1988; our data, 1981 Our data, 2005
	12.605447	109.334540	Rocky	
Hon Khoi Peninsula	12.574144*	109.244576*	Boulders with underlying sand	Kussakin et al., 1988; our data, 1980–1981
	12.589905*	109.226954*	Dead coral reef	

Table 1 (Continued)

Location	Latitude, N°	Longitude, E°	Substratum	References
Hon Gom Peninsula				
Cua Be Strait	12.575449	109.428198	Rocky-blocky-bouldery	Our data, 2005
	12.575951	109.426902	Sand with admixture of silt; rocky blocks	
	12.576055	109.427320	Sandy	
Thu Bay	12.601933	109.414524	Rocky blocks with underlying sand	Kussakin et al., 1988; our data, 1980–1981
Van Bay				
Do Islet	12.643920	109.376119	Rocky-blocky-bouldery	Our data, 2005
Ong Island	12.650649*	109.397971*	Dead coral reef	Kussakin et al., 1988; Nguyen Van Chung et al., 1988; our data, 1980–1982
			Pebbly	
			Boulders with underlying sand	
			Silted-sandy and sandy	
Mon Bay	12.659616*	109.408614*	Boulders with underlying sand	Kussakin et al., 1988; our data, 1980–1981
Nai Bay	12.685321	109.395147	Dead coral reef	
Co Co Strait				
Lutin Bay				
Sang Islet	12.646840*	109.343614*	Bouldery	Kussakin et al., 1988; our data, 1981
			Boulders with underlying sand	
Ke Bay	12.663915	109.349871	Dead coral reef	
Lon Strait	12.657237	109.335407	Boulders with underlying sand	Our data, 2005
Cape Co Co	12.663071*	109.328729*	Rocky Silted-sandy and sandy	Kussakin et al., 1988; our data, 1981

Table 1 (Continued)

Location	Latitude, N°	Longitude, E°	Substratum	References
Ben Goi Bay	12.650728	109.214006	Dead coral reef	Kussakin et al., 1988; our data, 1981
Me Islet	12.635863*	109.300699*	Rocky	Kussakin et al., 1988; Nguyen Van Chung et al., 1988; our data, 1980–1981
			Dead coral reef	
			Bouldery	
			Boulders with underlying sand	
Cum Meo Islet	12.641999*	109.218963*	Silted-sandy and sandy	Kussakin et al., 1988; our data, 1984
			Dead coral reef	
Ke Islet	12.643803*	109.316290*	Sand with admixture of silt, pebble and boulders	Kussakin et al., 1988; Nguyen Van Chung et al., 1988; our data, 1981
			Boulders with underlying sand	
Bip Islet	12.718656	109.295637	Dead coral reef	Kussakin et al., 1988; our data, 1981
Trau Nam Bay	12.775635	109.355167	Silted-sandy and sandy	
	12.795389	109.355511	Silted sand with admixture of shell and rare gravel	
Nua Islet	12.830350*	109.393395*	Bouldery	
			Rocky blocks and boulders with underlying sand	

Table 1 (Continued)

Location	Latitude, N°	Longitude, E°	Substratum	References
Ro Bay	12.862821	109.432643	Rocky blocks with underlying sand	Kussakin et al., 1988; our data, 1981
	12.863208	109.433769	Sandy	Our data, 1981
	12.876679	109.419961	Dead coral reef	Kussakin et al., 1988; Nguyen Van
	12.881351*	109.433206*	Rocky	Chung et al., 1988; our data, 1981
Nu Islet	Location unknown		Boulders with underlying sand	Kussakin et al., 1988; our data, 1980–1981
Re (Ly Son) Island	15.377606	109.140336	Sandy	Kostina et al., 1992; our data, 1988
	15.380585	109.139886	Dead coral reef	
Cham (Lao) Island	15.943044	108.511996	Sandy	
	15.943879	108.509057	Rocky-blocky-bouldery	
	15.944612	108.507264	Rocky	
Tien Sa (Son Tra) Peninsula	16.112668	108.313534	Rocky-blocky-bouldery	Kostina et al., 1992; our data, 1988
	16.117936	108.336818		
Gio (Co) Islet	17.156424	107.347997	Rocky-blocky-bouldery	
	17.160454	107.346462	Sandy	
Gulf of Tonkin The Red River Delta Day Estuary	19.915824*	106.075230*	Clayed silt	Gurjanova, Chang Hiu Phuong, 1972
	20.223252*	106.504919*		
	20.252914*	106.593238*		

Table 1 (Continued)

Location	Latitude, N°	Longitude, E°	Substratum	References
Con Lo Beach	20.475223*	106.615066*	Bouldery	Gurjanova, Chang Hiu Phuong, 1972
Van Uc Estuary	20.678614*	106.718807*	Clayed silt	
Dai Hop Beach	20.687273*	106.717372*	Silted sand with admixture of shell and clay (flats are covered by silt)	
Bang La Beach	20.706680*	106.749617*		
Trang Cat, An Kim Hai Canal	20.797171*	106.771874*	Clayed silt	Kostina et al., 1992; our data, 1988
Dinh Vu, Cam Estuary	20.806462*	106.787481*		
Bai Tu Long Archipelago				
Danh Do La (Ngoc Vung) Island	20.828148	107.349637		
Dao Trao (Van Canh) Island	20.872666	107.337309	Stony debris, coralline limestone, and shell covered by silt	Gurjanova, Chang Hiu Phuong, 1972
Cat Ba Island	20.8*	106.999722*	Rocky	
Be Bank			Silted-sandy	
Tran Ca Bank			Rocky	
			Silted-sandy	
Co To Island	20.960547*	107.763679*	Rocky	
	20.967103*	107.762497*	Sand with admixture of silt and rare boulders	

*Approximate location or location according to Geo URI (Uniform Resource Identifier for geographic locations).

Metal 250 and 500 cm² frames were used for sampling on loose substrata and 100, 250, and 500 cm² frames on hard substrata. Smaller frames were chosen for sampling in communities with small and more or less uniformly distributed organisms, and larger ones, for communities with fairly large or randomly distributed and rarely found organisms. We took two or three samples from each community. To remove bottom deposits from macrobenthic samples, we used a set of soil sieves. The collected samples were analyzed, all the organisms were registered and, after drying on a filter paper, weighed using pharmaceutical scales accurate to 10 mg; large plants were weighed on a technical balance accurate to 1 g. The obtained data were extrapolated for 1 m². The collections were fixed in 75% alcohol or 4% formalin.

The list of macrobenthos of the intertidal zone of Vietnam (see Appendix) was compiled from literature data and also from unpublished data of the authors. In addition to the literature directly related to the subject, the literature on some groups of macrobenthos of South China Sea was also used (Starobogatov, 1972; Strelzov, 1972; Latypov, 1986, 1988, 2007, 2014; Kalugina-Gutnik et al., 1988; Gulbin, Tran Dinh Nam, 1989; Kalashnikov, 1989; Levin, Dao Tan Ho, 1989; Murina, 1989, 2007; Zevina et al., 1992; Kussakin, Malyutina, 1993; Malyutina, 1994; Gulbin, Evseev, 1997; Moshchenko, 1997; Evseev, Lutaenko, 1998; Poltarukha, 2006, 2013; Dautova et al., 2007; Āuriš, 2007; Marin, Nguyen Thi Hai Thanh, 2007; Marin, Savinkin, 2007; Poltarukha, Dautova, 2007; Marin, 2008, 2012; Poltarukha, Zvyagintsev, 2008; Grintsov, Poltarukha, 2010; Kostina, 2011a; Latypov, Selin, 2011; Adrianov, Maiorova, 2012; Antokhina et al., 2012; Britayev, Antokhina, 2012; Chertoprud et al., 2012a, b; Martynov, Korshunova, 2012; Sirenko, 2012, 2016; Titlyanov, Titlyanova, 2012; Mekhova, Britayev, 2015; Zvonareva et al., 2015; Chaban, 2016; Chernyshev, 2016).

Intertidal zone of hard substrata

Rocky intertidal zone

The rocky intertidal zone was studied along the entire coast of Vietnam, from Nam Du Archipelago (Gulf of Thailand) in the south to Co To Island (Gulf of Tonkin) in the north (Table 1). This type of the intertidal zone is represented by rocky coast with a rather steep slope (30–90°) exposed to almost permanent wave action. The intertidal zone is 3–15 m wide. The vertical stratification of communities is well marked. The species composition and the dominant species of macrobenthic communities vary on different coasts, especially in the lower intertidal subzone depending on what algae or coral communities are developed here. But sedentary epifaunal forms dominate on the rocky intertidal zone.

The communities found in the supratidal zone and the upper intertidal subzone tend to exhibit poor species composition of macrobenthic fauna and flora. On the Nam Du Islet (Nam Du Archipelago), Catwick Islands, and Cham Island, a community dominated by the oyster *Saccostrea scyphophilla* (Fig. 2) forms a 0.5–1.5 m wide belt. The total biomass of macrobenthos can reach up to 12 kgWW m⁻², and *S. scyphophilla* makes up to 99% of the total biomass (Table 2). The subdominant group is represented by the barnacles *Tetraclita squamosa* or *Chthamalus malayensis*. Plantlets (0.7–1 cm high) of the red alga *Gelidium crinale* and the green alga *Valoniopsis pachynema* form patches up to 0.01–0.03 m² in area. In addition to quantitatively recorded species, this community includes the following motile organisms: the brachyuran crabs *Grapsus tenuicrustatus*, *Eriphia scabricula*, and *Percnon* sp., the gastropods *Echinolittorina millegrana*, *Dendropoma planorbis*, and *Vermetus tokyoensis*, as well as polychaetes and amphipods living in empty barnacle and oyster shells. On some capes of Cham Island, a community dominated by the gastropods *Cellana testudinaria*, *E. millegrana*, *Nerita albicilla*, and *Nerita* sp. is found in the upper subzone instead of the *S. scyphophilla* community; the gastropods do not form a belt (the total biomass of mollusks is about 660 gWW m⁻²).

To the north-west of the Gulf of Tonkin (Cat Ba and Co To islands, and Be Bank), the supratidal zone is inhabited by the littorinid species *Tectarius* sp. and the brachyuran crab *Nanosarman minutum*, which on the coasts protected from wave action spread to the middle intertidal subzone. There is a modification of the *S. scyphophilla* community dominated by *S. scyphophilla*+*Amphibalanus amphitrite* in the upper intertidal subzone. The other sessile species of the community include *Saccostrea echinata*, the barnacle *Ibla* sp., the mussels *Septifer* sp. and *Brachidontes* sp., and other bivalves (*Barbatia* sp. and *Pteria* sp.). Numerous small motile invertebrates: the brachyuran crabs *Parasesarma pictum*, *Myomenippe hardwickii*, *Halicarcinus orientalis*, *Eriphia*

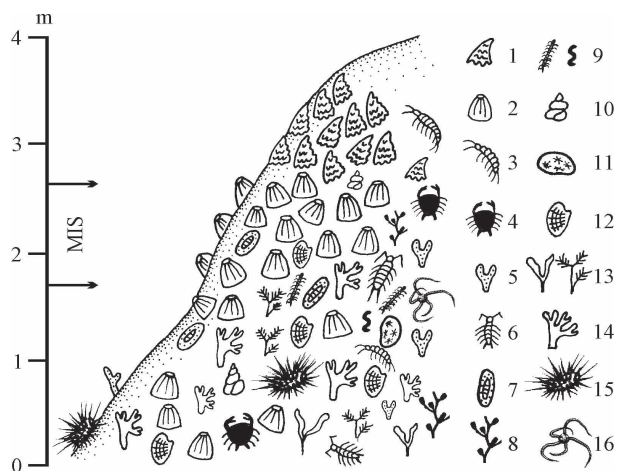


Fig. 2. Scheme of distribution of macrobenthos in the rocky intertidal zone (Grande Catwick, Catwick Islands). 1 – *Saccostrea scyphophilla*, 2 – *Megabalanus tintinnabulum*, 3 – Amphipoda, 4 – Decapoda, 5 – Spongia, 6 – Isopoda, 7 – Polychaeta, 8 – Hydrozoa, 9 – Polychaeta, 10 – Gastropoda, 11 – Zoantharia, 12 – Bivalvia, 13 – algae, 14 – Scleractinia, 15 – Echinoidea, 16 – Ophiuroidea. Vertical scale – range over depths 0. MIS – the middle intertidal subzone.

Table 2

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the upper intertidal subzone of the rocky intertidal zone, in the *Saccostrea scyphophilla* belt-forming community

Taxa	Taxonomic group	Grande Catwick, Catwick Islands		Cham Island	
		B	N	B	N
ANIMALS					
<i>Saccostrea scyphophilla</i>	Bi	12000.0	200	10008.0	1240
<i>Tetracrita squamosa</i>	Ci	–	–	590.0	160
<i>Isognomon ephippium</i>	Bi	–	–	48.0	480
<i>Septifer virgatus</i>	Bi	–	–	40.0	320
<i>Metopograpsus messor</i>	De	–	–	28.0	40
<i>Brachidontes mutabilis</i>	Bi	–	–	18.0	160
<i>Ibla cumingi</i>	Ci	–	–	12.2	160
<i>Entacmaea quadricolor</i>	Ac	–	–	12.0	200
<i>Trochus maculatus</i>	Ga	–	–	4.0	320
<i>Cellana testudinaria</i>	Ga	–	–	3.2	200
<i>Syllis hyalina</i>	Po	–	–	0.5	40
<i>Hyale</i> sp.	Am	0.4	120	–	–
<i>Dynamenella trachydermata</i>	Is	–	–	0.4	40
Total biomass		12000.4		10764.3	

Notes. See Tables 2, 4–22. Taxonomic groups: Rh – Rhodophyta, Och – Ochrophyta, Ch – Chlorophyta, Tra – Tracheophyta, Sp – Spongia, Hy – Hydrozoa, Ac – Actiniaria, Sc – Scleractinia, Zo – Zoantharia, Pr – Priapulida, Po – Polychaeta, Si – Sipuncula, Ci – Cirripedia, St – Stomatopoda, Cu – Cumacea, Ta – Tanaidacea, Is – Isopoda, Am – Amphipoda, De – Decapoda, Pol – Polyplacophora, Ga – Gastropoda, Bi – Bivalvia, Br – Brachiopoda, As – Asteroidea, Oph – Ophiuroidea, Ech – Echinoidea, Ho – Holothuroidea, Asc – Ascidiacea, Act – Actinopterygii. The sign «+» designates species found within the limits of a considered community, but their abundance is not registered, the sign «–» means that species is not found or quantity is not counted.

smithii, *Metopograpsus thukuhar*, and *Pinnotheres* sp., the porcelain crab *Petrolisthes* sp., and others nestle among sessile animals. There are also crustose coralline red algae. On the surf coasts, the coralline alga *Lithothamnion* spreads from the supratidal zone to the middle intertidal subzone, *S. echinata* disappears, and motile forms of invertebrates are absent (Gurjanova, Chang Hiu Phuong, 1972).

At Vung Tau, a belt-forming community, also dominated by the littorinid species *Tectarius antonii*, is found in the supratidal zone and the upper intertidal subzone (Fischer, 1952). On Thu Island, the population of the upper intertidal subzone is very poor. Only the littorinid species *Echinolittorina millegrana* and *T. antonii* very rarely occur in the rocky cracks.

The supratidal zone and the upper intertidal subzone from Cape Dinh to Ro Bay are occupied by belt-forming communities of Littorinidae and Littorinidae+Chthamalidae. The latter community spreads out to the upper part of the middle intertidal subzone (Fig. 3; Table 3). In the *Echinolittorina millegrana*+*Nodilittorina pyramidalis* community, the dominant and subdominant species can alternate themselves. *E. millegrana* prevails on Mieu and Lon (southern part) islands, Me Islet (Ben Goi Bay), and Cape Co Co, and in Cai Sung Bay, and *N. pyramidalis* is a quite common dominant species on Cape Dinh, Mot, Mieu, and Lon (north-eastern part) islands, Rua Islet (Nha Trang Bay), and in Ro Bay. Below the belt of Littorinidae, the *Chthamalus malayensis* community with predominance of the gastropod species



Fig. 3. The rocky intertidal zone in Tre Bay (Lon Island, Van Phong Bay). **A** – the general view, **B** – the upper intertidal subzone, **C** – belt of oysters in the middle intertidal subzone. Photograph by Alexey V. Chernyshev.

Table 3

Generalized scheme of the vertical distribution of the macrobenthic communities in the rocky and rocky-blocky-bouldery intertidal zones of Nha Trang and Van Phong bays (after Tran-ngoc Loi, 1967 and Kussakin et al., 1988)

Over depths 0, m	Intertidal subzone	Storey	Belt-forming communities
3.0	Supratidal zone		Belt of Littorinidae
2.5	Upper intertidal subzone	Upper	
2.0		Lower	
1.6	Middle intertidal subzone	Upper	Belt of Littorinidae+Chthamalidae (Tetracitidae or Balanidae)
1.35		Lower	
1.1	Lower intertidal subzone	Upper	Belt of Ostreidae
0.7		Lower	Belt of the algal mosaic (<i>Sargassum</i> , <i>Padina</i> , <i>Turbinaria</i> , the calcareous red algae, and others)
0			Belt of Cnidaria (Scleractinia, Alcyonacea, <i>Millepora</i>)

N. pyramidalis and *Patelloida saccharina* occurs. The red rock crab *Grapsus grapsus* can migrate all the way down the subtidal zone across the intertidal zone.

On Mieu Island (north-eastern part), Noi (Pecheurs Islets) and Than (Nha Trang Bay) islets, Cape Chut, Cape Hon Chong, and Cape Mong Ga (Table 1), a belt-forming community dominated by another littorinid species can be found, namely *Tectarius antonii*+*Echinolittorina miliaris*. In some locations, *Echinolittorina novaezelandiae* is also a dominant species. Usually just below belt of *Tectarius*, the upper subzone is occupied by the red alga *Bangia fuscopurpurea*, the green alga *Monostroma nitidum*, and the brown algae *Asteronema breviarticulatum*+*Chnoospora minima* communities. The projective cover of the bottom with algae comes up to 60–80%. However, in the north-eastern part of Mieu Island and on Cape Chut, these algal communities are absent (Tran-ngoc Loi, 1967).

In the middle intertidal subzone of Catwick Islands, a community dominated by the barnacle *Megabalanus tintinnabulum* forms a belt 3 m wide. The total biomass of macrobenthos is up to 11 kgWW m⁻² (Table 4), and *M. tintinnabulum* makes up above 90% of the total biomass. Red algae dominate among plants, and sponges and *Megabalanus* sp. prevail among animals. In addition to quantitatively recorded algae, there are the red algae *Asteromenia anastomosans*, *Asparagopsis taxiformis*, *Acrochaetium catenulatum*, *Jania pumila*, *Ceramium*

Table 4

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the middle intertidal subzone of the rocky intertidal zone, in the belt-forming communities of Cirripedia

Taxa	Taxonomic group	Catwick Islands				Cham Island	
		Petite	Catwick	Grande	Catwick	B	N
		B	N	B	N		
PLANTS							
<i>Hypnea pannosa</i>	Rh	–		176.4		–	
<i>Gelidium</i> sp.	Rh	+		135.0		–	
<i>Liagora</i> sp.	Rh	106.0		–		–	
<i>Gymnogongrus griffithsiae</i>	Rh	–		69.1		–	
<i>Polysiphonia</i> sp.	Rh	–		48.3		–	
<i>Gelidium crinale</i>	Rh	–		24.0		–	
<i>Lobophora variegata</i>	Och	+		13.3		–	
<i>Gayliella flaccida</i>	Rh	–		6.7		–	
<i>Cladophora</i> sp.	Ch	–		0.3		–	
Total biomass of plants		106.0		473.1			
ANIMALS							
<i>Megabalanus tintinnabulum</i>	Ci	11200.0	450	3745.0	467	–	–
<i>Tetracita squamosa</i>	Ci	+	+	–	–	6200.0	440
<i>Saccostrea scyphophilla</i>	Bi	–	–	–	–	3600.0	320
<i>Megabalanus</i> sp.	Ci	–	–	890.0	33	–	–
<i>Geodia</i> sp.	Sp	+		364.0		–	
<i>Halichondria</i> sp.	Sp	+		346.7		–	
<i>Septifer virgatus</i>	Bi	–	–	–	–	178.4	720
<i>Isognomon ephippium</i>	Bi	–	–	–	–	90.0	240
<i>Amphibalanus reticulatus</i>	Ci	–	–	81.7	533	–	–
<i>Leiosolenus levigatus</i>	Bi	–	–	5.0	33	42.8	160
<i>Metopograpsus messor</i>	De	–	–	–	–	30.0	680
<i>Balanus</i> sp.	Ci	–	–	26.7	267	–	–
<i>Brachidontes mutabilis</i>	Bi	–	–	–	–	18.0	160
<i>Actaea</i> sp.	De	–	–	14.7	33	–	–
Xanthidae	De	–	–	13.7	33	–	–
<i>Cellana testudinaria</i>	Ga	+	+	–	–	12.0	1000
<i>Perinereis cultrifera</i>	Po	–	–	–	–	11.8	600
Blenniidae	Act	–	–	–	–	10.4	80
<i>Nerita albicilla</i>	Ga	–	–	–	–	10.4	80
<i>Pachygrapsus minutus</i>	De	–	–	–	–	9.2	400
<i>Entacmaea quadricolor</i>	Ac	–	–	–	–	8.0	80

Table 4 (Continued)

Taxa	Taxonomic group	Catwick Islands				Cham Island	
		Petite Catwick		Grande Catwick			
		B	N	B	N	B	N
<i>Ischyrocerus</i> sp.	Am	+	+	7.0	867	–	–
<i>Allorchestes</i> sp.	Am	0.8	240	7.0	147	–	–
<i>Heteropanope glabra</i>	De	–	–	7.0	50	3.2	40
<i>Ibla cumingi</i>	Ci	–	–	–	–	4.0	40
Goneplacidae	De	–	–	3.3	17	–	–
<i>Spirobranchus giganteus</i>	Po	–	–	–	–	3.1	80
<i>Elasmopus</i> sp.	Am	–	–	2.9	1093	–	–
<i>Phascolosoma</i> (<i>Phascolosoma</i>) <i>nigrescens</i>	Si	–	–	–	–	2.8	40
<i>Dynoides amblysinus</i>	Is	0.2	120	2.4	447	–	–
<i>Pilumnus</i> sp.	De	+	+	2.0	13	0.4	80
<i>Marphysa sanguinea</i>	Po	–	–	–	–	1.8	40
<i>Pontogeneia</i> sp.	Am	–	–	1.7	67	–	–
<i>Palola siciliensis</i>	Po	–	–	1.7	33	–	–
<i>Nereis nicholli</i>	Po	+	+	1.3	100	–	–
<i>Lasaea undulata</i>	Bi	1.2	200	–	–	–	–
<i>Tetralia glaberrima</i>	De	1.2	40	–	–	–	–
<i>Dynamenella trachydermata</i>	Is	0.3	80	0.5	733	–	–
<i>Cirolana</i> sp.	Is	0.2	40	0.5	700	–	–
<i>Lachnopus subacutus</i>	De	–	–	–	–	0.4	40
<i>Sesarma</i> sp.	De	–	–	–	–	0.4	80
<i>Nereis</i> sp.	Po	–	–	0.5	233	–	–
<i>Syllis variegata</i>	Po	–	–	0.5	213	–	–
Tanaidacea	Ta	0.4	200	0.1	240	–	–
<i>Notoplax</i> sp.	Pol	0.4	40	–	–	–	–
<i>Amakusanthura</i> sp.	Is	0.3	80	0.1	67	–	–
<i>Reishia luteostoma</i>	Ga	+	+	0.3	67	–	–
<i>Caprella</i> sp.	Am	–	–	0.3	33	–	–
<i>Lysidice collaris</i>	Po	–	–	0.2	67	–	–
<i>Syllis hyalina</i>	Po	–	–	0.1	67	–	–
<i>Chrysopetalum debile</i>	Po	–	–	0.1	33	–	–
<i>Autolytus orientalis</i>	Po	–	–	0.1	33	–	–
<i>Maera</i> sp.	Am	–	–	0.1	30	–	–
Total biomass of animals		11205.0		5527.2		10237.1	
Total biomass		11311.0		6000.3		10237.1	

vietnamense, *Champia parvula*, and encrusting coralline red algae, the brown alga *Dictyota implexa* and the green algae *Dictyosphaeria versluisii*, *D. cavernosa* and *Valoniopsis pachynema*. Algal plantlets (0.5–0.9 cm high) of *Polysiphonia* sp., *Gelidiella acerosa*, *Lobophora variegata*, *Liagora* sp., and others are often found in the shells of barnacles and bodies of spongia with the projective cover of 60–100%. On the Catwick Islands, the sponge *Clathria (Thalysias) ramosa*, the scleractinian coral *Tubastraea coccinea*, the soft coral *Zoanthus* sp., diverse polychaetes (*Eunice kobiensis*, *Leodice antennata*, *Harmothoe asiatica*, *Parasphaerosyllis indica*, *Syllis gracilis*, *Dorvillea* sp., *Cirriiformia semicincta*), the barnacle *Chthamalus malayensis*, the little shore crab *Pachygrapsus minutus*, the species of gastropods (*Dendropoma planorbis*, *Drupa morum*, *Inquisitor varicosa*, *Diodora quadriradiata*, and *Mancinella alouina*), the brittle star *Ophiactis savignyi*, and some other invertebrates may also be found in the middle intertidal subzone. About 50% of barnacles on the Catwick Islands are dead.

On Grande Catwick, a community dominated by the scleractinian coral *Tubastraea coccinea* develops is recorded in rock clefts. The biomass of corals *T. coccinea* and *Stylophora pistillata* makes up 95% of the total biomass of macrobenthos (Table 5). Algae are not found in the community.

The belt-forming community of the barnacle *Tetracita squamosa* and the oyster *Saccostrea scyphophilla* is well developed in the middle intertidal subzone of Cham Island (Table 4). Algae are absent in the community. The animal biomass is up to 10 kgWW m⁻². The dominant species make up above 95% of the total biomass of macrobenthos.

On Nam Du Islet, the upper part of the middle intertidal subzone is occupied by the modification of the *Megabalanus tintinnabulum* community, the belt-forming community of *M. tintinnabulum* and the red alga *Laurencia* sp. The total biomass of macrobenthos reaches 3255 gWW m⁻² in the community. Among the accompanying species of algae, the red algae *Centroceras clavulatum* and *Leveillea jungermannioides* frequently occur, and among the animals, barnacle *Chthamalus malayensis*, rare Amphipoda, Polychaeta, and Actiniaria may be found in the community. The lower part of the middle intertidal subzone is inhabited by another algal community, a belt-forming community dominated by the brown alga *Turbinaria decurrens* with the total biomass of macrobenthos up to 4500 gWW m⁻². The community also includes the red algae *Laurencia* spp. and *L. jungermannioides*, *Jania spectabilis*, *Amphiroa frasilissima*, and others, species of Amphipoda, Polychaeta, Ophiuroidea, and *Cerithium* (Gastropoda).

On Thu Island, there are no distinct belts, and the distribution of communities is mosaic, with a slight predominance of the brown alga *Padina boryana* observed in the upper part of the middle intertidal subzone. Algal species also include the red

Table 5

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the middle intertidal subzone of the rocky intertidal zone, in the *Tubastraea coccinea* community (Grande Catwick, Catwick Islands)

Taxa	Taxonomic group	B	N
ANIMALS			
<i>Tubastraea coccinea</i>	Sc	1500.0	
<i>Stylophora pistillata</i>	Sc	448.0	
<i>Leiosolenus levigatus</i>	Bi	20.0	80
Calcarea	Sp	8.0	
<i>Sabia conica</i>	Ga	2.0	40
<i>Diodora quadriradiata</i>	Ga	2.0	40
<i>Ophiactis savignyi</i>	Oph	1.2	80
<i>Ischyrocerus</i> sp.	Am	0.8	80
<i>Autolytus orientalis</i>	Po	0.8	40
<i>Lysidice collaris</i>	Po	0.6	40
<i>Elasmopus</i> sp.	Am	0.4	40
<i>Sertularella</i> sp.	Hy	0.4	
<i>Dynamenella trachydermata</i>	Is	0.2	200
<i>Syllis variegata</i>	Po	0.2	80
<i>Amakusanthura</i> sp.	Is	0.1	40
<i>Cirolana</i> sp.	Is	0.1	40
<i>Dynoides amblysinus</i>	Is	0.1	40
Total biomass		1984.9	

algae *Gelidiella acerosa* and *Centroceras clavulatum* and the brown alga *Hydroclathrus clathratus* and animals are represented only by the gastropod *Drupa* sp. The belt of the brown alga *Sargassum mcclurei*, with the biomass above 4 kgWWm², develops in the lower part of the middle subzone. Sponges and gastropods predominate in the community.

At Vung Tau, the belt-forming community dominated by the oyster *Saccostrea cucullata* is characteristic for habitats with weak wave action. On wave-exposed coasts, settlements of the barnacle *Tetraclita porosa* develop. Settlements of the gastropod *Nerita albicilla* are also frequent in the middle intertidal subzone on rocks (Fischer, 1952).

From Cape Dinh to Ro Bay, on Than Islet, Cape Chut and Cape Mong Ga, a belt-forming community dominated by the barnacle *Chthamalus malayensis* develops in the middle intertidal subzone. Below the belt of barnacles, there is a belt of

the oyster *Saccostrea cucullata*. On Noi Islet and Cape Hon Chong, the *Ch. malayensis* community spreads mainly in the lower part of the upper intertidal subzone with separate settlements in the middle subzone. In the north-eastern part of Mieu Island, the *S. cucullata* community occupies most part of the middle intertidal subzone forming a 60 cm wide belt. A community dominated by the red alga *Dermonea virens* and the green alga *Chaetomorpha antennina* has a patchy distribution in the middle intertidal subzone of Noi and Than islets, Cape Hon Chong and Cape Mong Ga (Tran-ngoc Loi, 1967).

On Mieu and Lon (southern part and Tre Bay) islands, Me Islet, in Cai Sung Bay and on Cape Co Co, the lower part of the middle intertidal subzone and almost the whole upper part of the lower intertidal subzone of rocks are occupied by a belt-forming 60–75 cm wide community dominated by another species of oysters, namely *Saccostrea scyphophilla* (Fig. 3). In some locations, the barnacle *Tetraclita* belt may be found between *Chthamalus* and *Saccostrea*. And besides, zones subject to strong surf action are inhabited by *Tetraclita squamosa*, whereas *T. porosa* develops in more sheltered areas. *Chthamalus* is sometimes replaced by *Megabalanus tintinnabulum*. Among dead oysters, diverse species of Polychaeta, Decapoda, and Bivalvia can frequently be found.

To the north-west of the Gulf of Tonkin (Cat Ba and Co To islands, and Be Bank), dense settlements of the barnacle *Balanus* sp. occur in the middle intertidal subzone. The brachyuran crab *Nanosesarma minutum* and rare *Ibla* sp. barnacles are accompanying the dominant species (Gurjanova, Chang Hiu Phuong, 1972).

On Nam Du Islet, the species composition of macrobenthos is very poor in the lower intertidal subzone. The brown alga *Lobophora variegata* makes up to 95% of total algal biomass, which is quite low (143 gWWm^{-2}), and among animals only species of Polychaeta occur.

On Thu Island, the lower intertidal subzone is occupied by a belt-forming community dominated by the brown alga *Sargassum feldmannii* with the total macrobenthic biomass of about 1500 gWWm^{-2} . The green algae *Caulerpa racemosa* and *Halimeda bikinensis* are prevailing species of algae and among animals only Polychaeta, Amphipoda, and Isopoda may be found, with a very small share (0.08 gWWm^{-2}) in the community.

On the Catwick Islands, communities of the middle intertidal subzone dominated by barnacles spread along the lower intertidal subzone. The total animal biomass is above 10 kgWW m^{-2} (Table 6). In addition to quantitatively recorded species of algae, the red algae *Peyssonnelia* sp., *Acrochaetium catenulatum*, *Ceramium vietnamense*, *Ahnfeltiopsis quinhonensis*, *Ceratodictyon repens*, *C. scoparium*, *Gelidiella myrioclada*, and *Jania pumila*, the brown alga *Neoralfsia expansa* and the green alga *Chlorodesmis hildebrandtii* occur in these communities. The red alga *Hypnea nidulans*

Table 6

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos
in the lower intertidal subzone of the rocky intertidal zone,
in the *Megabalanus* communities (Catwick Islands)

Taxa	Taxonomic group	Petite Catwick		Grande Catwick	
		B	N	B	N
PLANTS					
<i>Gayliella flaccida</i>	Rh	222.0		–	
<i>Dictyosphaeria cavernosa</i>	Ch	191.8		–	
<i>Asteromenia anastomosans</i>	Rh	–		43.2	
<i>Gelidium crinale</i>	Rh	–		24.0	
Total biomass of plants		413.8		67.2	
ANIMALS					
<i>Megabalanus tintinnabulum</i>	Ci	–	–	10840.0	3280
<i>Megabalanus</i> sp.	Ci	9600.0	440	–	–
<i>Eupilumnus actumnoides</i>	De	524.0	440	–	–
<i>Drupa morum</i>	Ga	380.0	40	+	+
Calcarea	Sp	360.0		–	
Xanthidae	De	1.2	40	8.0	40
<i>Sertularia</i> sp.	Hy	3.2		+	
<i>Syllis variegata</i>	Po	1.3	240	–	–
<i>Nereis nichollsi</i>	Po	1.1	200	–	–
<i>Ischyrocerus</i> sp.	Am	0.8	1360	–	–
Tanaidacea	Ta	0.8	1200	–	–
<i>Leodice antennata</i>	Po	0.8	40	–	–
<i>Diodora quadriradiata</i>	Ga	0.8	40	–	–
<i>Reishia luteostoma</i>	Ga	0.8	40	–	–
<i>Dynamenella trachydermata</i>	Is	–	–	0.7	160
<i>Syllis gracilis</i>	Po	0.5	320	–	–
<i>Plaxiphora</i> sp.	Pol	–	–	0.4	80
<i>Schizotricha</i> sp.	Hy	–		0.4	
<i>Phascolosoma</i> (<i>Phascolosoma</i>) <i>nigrescens</i>	Si	0.4	80	–	–
<i>Notoplax</i> sp.	Pol	0.4	80	–	–
<i>Chrysopetalum debile</i>	Po	0.3	40	–	–
<i>Maera</i> sp.	Am	0.2	80	–	–
<i>Cirolana</i> sp.	Is	–	–	0.1	40
<i>Dynoides amblysinus</i>	Is	–	–	0.1	40
Total biomass of animals		10876.6		10849.7	
Total biomass		11290.4		10916.9	

may occupy shells of large mollusks. The projective cover of rocks by crustose coral-line red algae is 70–80%. The sponges *Tedania* (*Tedania*) *anhelans*, *Spongia* sp., and *Gelliodes* sp., the scleractinian corals *Tubastraea coccinea* and *Pocillopora verrucosa*, various species of Decapoda and Echinoidea, the gastropods *Menathais tuberosa*, *Mancinella alouina*, and *Latirolagena smaragdulus*, the bivalve mollusk *Tridacna* sp. are also found among animals in the lower intertidal subzone on the Catwick Islands. The corals *T. coccinea* and *P. verrucosa* spread in the subtidal zone where they create continuous fields.

At Vung Tau, the lower intertidal subzone of rocks is mainly inhabited by diverse brown algae, sessile invertebrates (species of Serpulidae, Cirripedia, and oysters), and by the gastropods (*Monodonta canalifera*, *Patelloida saccharina*, *Cellana testudinaria*, *C. bifasciata*, *Reishia luteostoma*, *Pictocolumbella ocellata*, *Mitra scutulata*, and others) (Fischer, 1952).

The macrobenthos of the lower intertidal subzone below the belt of oysters varies from Cape Dinh to Ro Bay. For example, the sedentary gastropod *Thylacodes* sp. (up to 1350 gWWm⁻²) often forms a belt over coral communities of Lon Island. The true limpet *Scutellastra flexuosa* and the chiton *Acanthochitona fascicularis* may be found in the *Thylacodes* community.

On Mieu and Lon (southern part and Tre Bay) islands, Me Islet, in Cai Sung Bay and on Cape Co Co, rocky cracks filled with sand and small stony debris host a diverse fauna of invertebrates: gastropods (*C. testudinaria*, *P. saccharina*, *Nerita undata*, *N. albicilla*, *Planaxis sulcatus*, *Thalessa aculeata*, *Mancinella armigera*, *R. luteostoma*, *Drupa ricinus*, *Tenguella musiva*, *Chicoreus brunneus*, *P. ocellata*, and *Conus sponsalis*), bivalve mollusks (*Barbatia foliata*, *B. cometa*, *Striarca symmetrica*, *Trapezia speciosa*, *Ostrea* sp., *Saccostrea scyphophilla*, *Isognomon perna*, *I. isognomum*, *Septifer excisus*, *Malleus legumen*, *Leiosolenus malaccanus*, *Pinctada margaritifera*, *Spondylus sinensis*, and *Periglypta reticulata*), the chiton *Liolophura* sp., the barnacle *Capitulum mitella*, the porcelain crab *Petrolisthes boscii*, and the sea urchin *Actinopyga echinites*.

The lower part of the lower intertidal subzone, the subtidal fringe, and the subtidal zone are inhabited by colonies of various scleractinian corals forming massive reef structures. For instance, the scleractinian corals *Montipora angulata*, *Goniastrea pectinata*, *G. retiformis*, *G. aspera*, *Favia speciosa*, *F. favus*, *F. pallida*, *Acropora secale*, *A. divaricata*, *A. hyacinthus*, *A. robusta*, *Porites lobata*, *Leptastrea purpurea*, *Pocillopora damicornis*, and *P. verrucosa* are the main reef builders on Mieu Island. In Cai Sung Bay and other areas, besides, the scleractinian corals *Stylophora pistillata*, *Acropora digitifera*, *Fungia fungites*, *F. scutaria*, *Porites australiensis*, *G. aspera*, *Galaxea fascicularis*, and colonies of the hydrocoral *Millepora platyphylla* occur. Diverse species of gastropods (*C. testudinaria*, *N. albicilla*, *Planaxis sulcatus*, *Thalessa*

aculeata, *Tenguella granulata*, *Purpura persica*, *Mauritia arabica*, *Cantharus* sp., and others), bivalve mollusks (*Arca ventricosa*, *Chama* sp., *Leiosolenus lima*, *L. levigatus*, *L. malaccanus*, *S. scyphophylla*, *Gastrochaena* sp., and *Pinctada* sp.), sponges, sea cucumbers, small brittle stars, crabs (*Brachyura* and *Anomura*), shrimps (*Alpheidae*), and ascidians live in the coral communities. Less often, sipunculid worms, polychaetes, the barnacles *Megabalanus tintinnabulum* and *Capitulum mitella*, the coral fishes *Gobiodon*, and the brown alga *Lobophora* sp. can be found living among coral branches. Numerous highly mobile blennioid fishes of the genus *Salaria* swarm below the water surface. However, though the species diversity of animals is high in the coral communities, the total animal biomass without corals is extremely low (95 gWWm^{-2}). From Cape Dinh to Ro Bay, a wide belt of *Sargassum* develops in the lower intertidal subzone.

In Cai Sung Bay, there is a dead coral plateau with rare rocky blocks. This part of the plateau is inhabited by several species of sea cucumbers, the sea urchin *Eremopyga* sp., several species of sponges, brachyuran crabs, and sipunculid worms, *Clibanarius* sp. and other hermit crabs, the mantis shrimp *Gonodactylus* sp., the gastropods *Thalessa aculeata* and *Turbo bruneus*, and the bivalve mollusks *Chama brassica*, *A. ventricosa*, *Septifer bilocularis*, *Isognomon perna*, *Pinna saccata*, *Pinctada imbricata fucata*, *Lithophaga caperata*, *Barbatia foliata*, and *Modiolus auriculatus*. Occasionally several species of opisthobranchs, amphipods, and a few shrimps occur. The limestone calyces of dead corals are inhabited by the polychaete *Hediste diversicolor* up to 60 cm long and by moray eels. There are a few algal species (the green algae *Valonia*, the brown algae *Padina*, the red alga *Gymnogongrus griffithsiae*, and others) in the upper part of the plateau. In the lower part, algae are more diverse (the green algae *Caulerpa microphysa*, *Boodlea struveoides*, and *Anadyomene plicata*, and the red algae *Palisada perforata*, *Laurencia tenera*, *Gracilaria canaliculata*, and *Gelidiella acerosa*), and their total biomass is up to 300 gWWm^{-2} . The total animal biomass reaches 4500 gWWm^{-2} , and bivalve and gastropod mollusks prevail among animals (more than 65% and about 30% of the total biomass respectively). Bivalves include *Striarca symmetrica*, *A. ventricosa*, *Adula* sp., *Rocellaria* sp., *Cardita variegata*, *Isognomon perna*, *I. isognomum*, *M. auriculatus*, *Malleus legumen*, and *Leiosolenus malaccanus*. Among gastropods, *Conus* sp. and *Turbo bruneus* predominate and sometimes *Cerithium* sp. and *Drupa* sp. are found. Species of Decapoda, Holothuroidea, Polychaeta, and Amphipoda frequently occur below a belt of oysters in the lower intertidal subzone of Cai Sung Bay.

On Noi Islet, there are communities of *Megabalanus tintinnabulum*+*Lobophora variegata*, the worm snail *Dendropoma corrodens*, the green alga *Chaetomorpha antennina*, and other organisms that do not form belts. The main belt-forming communities are represented by the crustose coralline algae *Hydrolithon*, *Neogoniolithon*,

and *Lithophyllum* and algal turf dominated by the red alga *Gelidium pusillum*. The subtidal fringe is inhabited by scleractinian corals. On Cape Chut, association of the brown algae *Sargassum polycystum*, *Turbinaria ornata*, and *Padina boryana* form a belt in the upper part of the lower subzone, and colonies of scleractinian corals form settlements in the lower part of subzone. Reef-building scleractinian corals with diverse accompanying fauna and flora flourish in the north-eastern part of Mieu Island. A belt of crustose coralline algae *Lithophyllum* and *Peyssonnelia* is also quite extended. The low intertidal subzone of Than Islet is mainly occupied by a belt-forming *M. tintinnabulum*+*Tetracrita squamosa* community. On Cape Hon Chong, *Sargassum mclurei*+*Sargassum polycystum* form a belt, and most part of the lower intertidal subzone is inhabited by colonies of the hydrocoral *Millepora platyphylla*, reef-building scleractinian corals and species of Alcyonaria. On Cape Mong Ga, a belt-forming community dominated by the barnacle *M. tintinnabulum* and the brown alga *Lobophora variegata*, and a belt of the crustose coralline algae *Hydrolithon* and *Neogoniolithon* spread along the lower intertidal subzone. Communities of the brown algae *Sargassum aquifolium* and *Dictyota friabilis* are also widespread here (Tran-ngoc Loi, 1967).

A community of the barnacle *Tetracrita squamosa* is developed both in the middle intertidal subzone and in the lower intertidal subzone on Cham Island. The species composition of macrobenthos is characterized by rather low diversity. The brown algae *L. variegata*, *Sargassum* sp., *Turbinaria ornata*, and *Padina australis*, the green algae *Dictyosphaeria cavernosa* and *Caulerpa racemosa*, the red algae *Peyssonnelia* sp., *Lithothamnion* sp., and other crustose red algae are found in the lower intertidal subzone. Macrophytic algae may often be observed as destroyed thalli, plantlets, or only rhizoids in the rocky intertidal zone. The green alga *Phyllocladon anastomosans* may dwell on the colonies of hard scleractinian corals. Among animals, in addition to the dominant species, the sponge *Gelliodes* sp., the soft zoantharian coral *Palythoa tuberculosa*, the sipunculid worm *Phascolosoma* (*Phascolosoma*) *scolops*, the brachyuran crab *Chlorodiella* sp., the gastropod mollusk *Clypeomorus bifasciata*, and the bivalve mollusk *Saccostrea scyphophilla* frequently occur in the lower rocky intertidal subzone of Cham Island.

To the north-west of the Gulf of Tonkin (Cat Ba and Co To islands, and Be Bank), the crustose coralline alga *Lithothamnion* forms a belt and provides a variety of habitats for numerous Loricata (Gurjanova, Chang Hiu Phuong, 1972).

Rocky-blocky-bouldery intertidal zone

The rocky-blocky-bouldery intertidal zone (Thu, Mieu, Lon, and Cham islands, Mok (Nam Du Archipelago), Do (Van Bay), and Gio islets, Hon Gom Peninsula (Cua Be Strait) and Tien Sa Peninsula) (Table 1) is characterized by rocky blocks

and boulders in the upper and middle intertidal subzones, rocks with a slope up to 90°, rocky blocks and boulders with underlying sand in the lower intertidal subzone. The intertidal zone may reach 20–30 m in width. There are belt-forming communities in the upper and middle intertidal subzones and in the lower intertidal subzone communities are arranged in a patchy pattern. Dominant species vary in the communities from site to site, but, similarly to the rocky intertidal zone, epifauna prevails here.

In the southern part of Vietnam, in the upper intertidal subzone of Thu Island, macrobenthic animals inhabit only tide pools, but a rather rich composition of animals and plants is typical for the middle intertidal subzone. The green algae *Halimeda opuntia*, *H. discoidea*, *Caulerpa serrulata*, *C. racemosa*, *C. taxifolia*, *C. sertularioides*, and *Dictyosphaeria cavernosa* form a basis of the belt-forming community. Other algae include Rhodophyta (*Mastophora rosea*, *Gelidium* sp., *Laurencia corymbosa*, and *Melyvonnea erubescens*) and Phaeophyceae (*Dictyota* sp.). The seagrass *Thalassia* sp. grows on sandy patches, which split rocky bottom. The middle intertidal subzone of Thu Island is abundant with diverse corals (*Heliopora coerulea*, *Pocillopora verrucosa*, *Porites lutea*, *Goniastrea pectinata*), gastropods (*Monetaria moneta*, *Monodonta labio*, *Conus ebraeus*, *Tenguella granulata*, *Reticutriton pfeifferianus*, *Vasum turbinellus*, *Trochus maculatus*, opisthobranchs, and others), sponges, hermit crabs, the brittle stars *Ophiocoma erinaceus* and *Amphipholis squamata*, and the isopod *Joeropsis* sp.

In the lower intertidal subzone, the belt of algae can reach 10–15 m in width. Sandy patches splitting the rocky bottom off Thu Island are frequently occupied by red algae (*Mastophora rosea*, *Laurencia corymbosa*, *Melyvonnea erubescens*, *Lithophyllum okamurae*, *Asteromenia anastomosans*, *Centroceras clavulatum*, *Gelidium* sp., and others) and green algae (*Caulerpa taxifolia*, *C. racemosa*, *Halimeda opuntia*, *H. discoidea*, and *Boodlea struveoides*). The brown alga *Sargassum* sp. is found as destroyed thalli. The total algal biomass is 500–600 gWWm⁻². A diversity of hard corals (*Montipora digitata*, *M. spongodes*, *Porites australiensis*, and *Heliopora coerulea*), polychaetes (*Nereiphylla castanea*, *Paralentia annamita*, *Typosyllis maculata*, *Cirriformia semicincta*, *Terebellides stroemii*, and *Leodice antennata*), isopods (*Aphantolana sphaeromiformis*, *Paracilicaca asiatica*, *Cerceis pravipalma*, *Zuzara digitata*, and *Z. curtispina*), gastropods (*Clypeomorus bifasciata*, *Pictocolumbella ocellata*, *Drupella rugosa*, *Conus lividus*, *C. ebraeus*, *Menathais tuberosa*, and others), brittle stars (*Ophiocoma erinaceus* and *Amphipholis squamata*), the chiton *Ischnochiton* sp., free-living flatworms of the order Tricladida, mantis shrimps, amphipods, and decapods inhabit the lower intertidal subzone of Thu Island.

On Mieu and Lon islands, Do Islet, and in Cua Be Strait, the supratidal zone and the upper intertidal subzone are inhabited by a community of

gastropod mollusks Littorinidae (Fig. 4) with the rather low total biomass of macrobenthos (about 30 gWWm⁻²). The gastropods *Nodilittorina pyramidalis*, *Echinolittorina feejeensis*, and *Peasiella* sp. predominate. Besides, *Tenguella musiva* and *Nerita undata* (Gastropoda), the bivalve mollusk *Isognomon* sp., the barnacle *Tetraclita* sp., hermit crabs, and goose barnacles are found in the community. The lightfoot crabs of the genus *Grapsus* and the fishes of the genus *Salarias* are traveling across the intertidal zone.

Settlements of the barnacle *Chthamalus* sp. are found in the upper part of the middle intertidal subzone. The lower part of the subzone is occupied by a belt-forming community of the oyster *Saccostrea cucullata* up to 75 cm wide with the biomass of dominant species reaching 290 gWWm⁻². Below *Chthamalus* and over *Saccostrea*, sometimes *Tetraclita* settlements occur (Fig. 5).

The upper part of the lower intertidal subzone is occupied by the bivalve mollusk *Malleus regula*. Among other animals, various species of Gastropoda and Stomatopoda frequently occur, and species of Polychaeta are uncommon. The population of the lower part of the lower intertidal subzone differs between Nha Trang and Van Phong bays. Colonies of the hydrocoral *Millepora platyphylla*, reef-building scleractinian corals and species of Alcyonaria form dense accumulations in Van Phong Bay (Fig. 6). In Nha Trang Bay, a belt of algal mosaic dominated by the brown algae of the genera *Sargassum* and *Padina* and calcareous red and green algae are observed between oysters and corals. Members of Gastropoda, Stomatopoda, Hydrozoa, and Echinodermata form accompanying fauna in the communities of the lower intertidal subzone.

In the central part of Vietnam, on Cham Island, a community dominated by the gastropod species *Echinolittorina millegrana* forms a 3–5 m wide belt, and *E. millegrana* makes up 99% of the total community biomass in the upper intertidal subzone. The gastropods *Nerita albicilla*, *Mancinella alouina*, *Cellana testudinaria*, *Drupella margariticola*, *D. rugosa*, *Conus* sp., and others, and the brachyuran crab *Grapsus tenuicrustatus* are accompanying species.

On Tien Sa Peninsula, a community of the oyster *Saccostrea scyphophilla* forms a 5–7 m wide belt. The barnacle *Pollicipes* sp. and the gastropod *Nerita albicilla* also prevail in the community (Fig. 7; Table 7). The *S. scyphophilla* community also includes the barnacle *Scalpellum typicum*, the brachyuran crab *Grapsus tenuicrustatus*, hermit crabs, and the gastropods *Mancinella alouina* and *Monodonta labio*. On Gio Islet, a belt-forming community dominated by the barnacle *Tetraclita squamosa* and abundant with gastropods (*N. albicilla* and *Planaxis sulcatus*) and crabs (*G. tenuicrustatus*) develops in the upper intertidal subzone.

A rich composition of macrobenthos is typical for the middle intertidal subzone. On Cham Island and Gio Islet, the *S. scyphophilla* community forms



Fig. 4. The rocky-blocky-bouldery intertidal zone on Do Islet (Van Bay, Van Phong Bay). **A** – the general view, **B** – the upper intertidal subzone. Photograph by Alexey V. Chernyshev.



Fig. 5. The rocky-blocky-bouldery intertidal zone on Mieu Island. Photograph by Alexey V. Chernyshev.



Fig. 6. The rocky-blocky-bouldery intertidal zone on the south-western coast of Hon Gom Peninsula (Cua Be Strait, Van Phong Bay). **A** – the general view, **B** – coral reef in the lower intertidal subzone. Photograph by Alexey V. Chernyshev.

a 5–8 m wide belt. The total biomass of macrobenthos may reach up to 11.5 kgWW m⁻² (Table 8). Algae are absent in this community with an exception of the calcareous red alga *Lithothamnion* sp. covering boulders and rocky blocks on Gio Islet. The species composition of the community is rather diverse, but gastropods and hermit crabs mainly prevail. Numerous small specimens of brachyuran crabs occur under boulders covered by the sponge *Timea* sp. on Gio Islet.

On Tien Sa Peninsula, there are two communities in the middle intertidal subzone. A community of the red algae

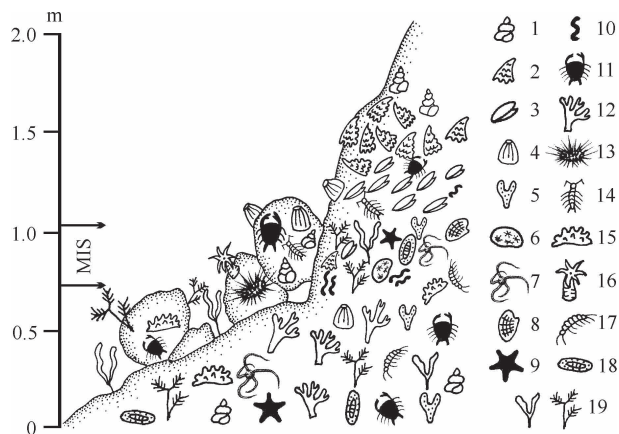


Fig. 7. Scheme of distribution of macrobenthos in the rocky-blocky-bouldery intertidal zone (Tien Sa Peninsula). 1 – Gastropoda, 2 – *Saccostrea scyphophilla*, 3 – *Pollicipes* sp., 4 – Cirripedia, 5 – Spongia, 6 – Zoantharia, 7 – Ophiuroidea, 8 – Bivalvia, 9 – Asteroidea, 10 – Polychaeta, 11 – Decapoda, 12 – Scleractinia, 13 – Echinoidea, 14 – Isopoda, 15 – Holothuroidea, 16 – Actiniaria, 17 – Amphipoda, 18 – Polyplacophora, 19 – algae and seagrasses. Vertical scale – range over depths 0. MIS – the middle intertidal subzone.

Table 7

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the upper intertidal subzone of the rocky-blocky-bouldery intertidal zone

Taxa	Taxonomic group	Gio Islet		Tien Sa Peninsula			
				northward of Cape Lutin		south-eastern part	
		B	N	B	N	B	N
ANIMALS							
<i>Tetraclista squamosa</i>	Ci	2501.0	300	–	–	–	–
<i>Saccostrea scyphophilla</i>	Bi	–	–	2500.0	68	1200.0	136
<i>Pollicipes</i> sp.	Ci	–	–	535.0	170	–	–
<i>Planaxis sulcatus</i>	Ga	455.0	300	+	+	56.6	64
<i>Nerita albicilla</i>	Ga	110.0	100	117.5	90	–	–
<i>Cellana vitiensis</i>	Ga	–	–	24.6	60	–	–
<i>Chthamalus malayensis</i>	Ci	–	–	–	–	17.0	840
<i>Echinolittorina millegrana</i>	Ga	–	–	+	+	5.4	280
<i>Sesarma</i> sp.	De	–	–	0.1	10	–	–
<i>Perinereis cultrifera</i>	Po	–	–	0.1	10	–	–
Total biomass		3066.0		3177.3		1279.0	

Gelidiella acerosa+*Gelidium crinale* is found northward of Cape Lutin (Table 8). The algal flora includes encrusting coralline red algae that cover significant areas of rocky walls, blocks, and boulders, as well as the green alga *Dictyosphaeria cavernosa*, the brown algae *Lobophora variegata*, *Neoralsia expansa*, and *Turbinaria ornata*, and others. The sea cucumber *Holothuria* sp., colonies of the soft coral *Palythoa tuberculosa* of the order Zoantharia, and the sea urchin *Echinothrix calamaris* dominate among animals. In addition to quantitatively recorded species, other holothurians, *Holothuria* (*Mertensiothuria*) *hilla* and *H.* (*Thymiosycia*) *impatiens*, the polychaete *Nereis nichollsi*, the barnacle *Tetraclita squamosa*, the isopod *Ligia* sp., the amphipod *Hyale* sp., the gastropods *Cellana testudinaria*, *Tenguella granulata*, *Drupella margariticola*, and some opisthobranchs, the bivalve mollusk *Barbatia foliata*, and the sea star *Echinaster* sp. are found in the algal community.

In the south-eastern part of Tien Sa Peninsula, a community dominated by the barnacle *Pollicipes* sp. develops. Very diverse plants, especially red algae (*G. acerosa*, *G. crinale*, *Palisada parvipapillata*, and encrusting coralline red algae), and the seagrass *Thalassia* sp. are recorded in the community. Nevertheless, many algae are found only in the form of destroyed thalli (the green algae *D. cavernosa* and *Neomeris annulata*), plantlets (the brown algae *Padina australis* and *Sargassum* sp.), or rhizoids (*T. ornata*). The sea snail *Echinolittorina millegrana* is the first numerous animal species (more than 2300 ind. m⁻²). The chitons *Lucilina* sp. and *Plaxiphora* sp.

Table 8

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the middle intertidal subzone of the rocky-blocky-bouldery intertidal zone

Taxa	Taxonomic group	Cham Island		Tien Sa Peninsula			
				northward of Cape Lutin		south-eastern part	
		B	N	B	N	B	N
PLANTS							
<i>Gelidiella acerosa</i>	Rh	–		256.0		+	
<i>Gelidium crinale</i>	Rh	–		210.0		+	
Coralline red algae	Rh	–		40.0		+	
<i>Lithothamnion</i> sp.	Rh	–		24.0		–	
<i>Sargassum</i> sp.	Och	–		18.0		+	
<i>Jania</i> sp.	Rh	–		4.0		–	
<i>Padina australis</i>	Och	–		2.0		+	
<i>Asparagopsis taxiformis</i>	Rh	–		0.5		–	
Total biomass of plants				554.5			

Table 8 (Continued)

Taxa	Taxonomic group	Cham Island		Tien Sa Peninsula			
				northward of Cape Lutin		south-eastern part	
		B	N	B	N	B	N
ANIMALS							
<i>Saccostrea scyphophilla</i>	Bi	8400.0	560	–	–	+	+
<i>Nerita albicilla</i>	Ga	1620.0	360	+	+	40.0	33
<i>Mancinella alouina</i>	Ga	964.0	160	+	+	+	+
Paguridae	De	284.8	40	–	–	+	+
<i>Pollicipes</i> sp.	Ci	–	–	–	–	233.3	67
<i>Conus</i> sp.	Ga	220.0	40	–	–	–	–
<i>Holothuria</i> sp.	Ho	–	–	204.0	20	–	–
<i>Palythoa tuberculosa</i>	Zo	–		155.6		–	
<i>Echinothrix calamaris</i>	Ech	–	–	130.6	20	–	–
Actiniaria	Ac	–	–	84.0	120	–	–
<i>Drupella rugosa</i>	Ga	84.0	80	20.0	40	+	+
<i>Echinolittorina millegrana</i>	Ga	–	–	0.6	20	53.3	2367
<i>Monodonta labio</i>	Ga	–	–	–	–	50.0	33
<i>Leiosolenus levigatus</i>	Bi	–	–	42.0	80	–	–
<i>Planaxis sulcatus</i>	Ga	–	–	–	–	33.3	100
<i>Cellana toreuma</i>	Ga	–	–	0.4	20	15.3	40
<i>Spirobranchus giganteus</i>	Po	–	–	14.2	280	–	–
<i>Petrosia</i> sp.	Sp	–		3.2		–	
<i>Haliclona</i> sp.	Sp	–		2.0		–	
<i>Brachidontes mutabilis</i>	Bi	–	–	2.0	20	–	–
<i>Palola siciliensis</i>	Po	–	–	1.2	40	–	–
<i>Calcinus</i> sp.	De	–	–	1.0	20	–	–
<i>Isognomon isognomum</i>	Bi	0.8	40	–	–	–	–
<i>Zozymodes cavipes</i>	De	–	–	0.8	20	–	–
<i>Pachygrapsus minutus</i>	De	–	–	0.4	24	–	–
<i>Lepidonotus tenuisetosus</i>	Po	–	–	0.4	20	–	–
Photidae	Am	–	–	0.2	24	–	–
<i>Lanocira anasicula</i>	Is	–	–	0.2	20	–	–
<i>Perinereis</i> sp.	Po	–	–	0.2	8	–	–
<i>Lysidice collaris</i>	Po	–	–	0.2	8	–	–
<i>Pilumnus</i> sp.	De	–	–	0.1	8	–	–
Total biomass of animals		11573.6		663.3		425.2	
Total biomass		11573.6		1217.8		425.2	

are frequently found on boulders and under them. Other animals of the *Pollicipes* community include the barnacle *Tetrachita squamosa* and gastropods (*Cellana testudinaria*, *Nerita plicata*, and *N. insculpta*).

Mass development of algae and invertebrates, specifically hard corals, characterizes the lower intertidal subzone of the rocky-blocky-bouldery intertidal zone. The lower intertidal subzone of Tien Sa Peninsula hosts diverse algae (the red algae *Asparagopsis taxiformis*, *Peyssonnelia* sp., *Amphiroa* spp., *Gelidium crinale*, *Gelidium* sp., *Jania* sp., *Gelidiella acerosa*, *Dichotomaria marginata*, *Gymnogongrus* sp., *Palisada parvipapillata*, *Hypnea pannosa*, *H. nidulans*, *Lithophyllum okamurae*, *Laurencia brachyclados*, and others; the brown algae *Padina boryana*, *Lobophora variegata*, and *Dictyota* sp., the green algae *Dictyosphaeria cavernosa*, *Caulerpa microphysa*, and *Codium repens*). The projective cover of rocky blocks and boulders by encrusting coralline red algae is 50–60%. Some brown algae are found in form of destroyed thalli (*Turbinaria ornata*) and plantlets (*Sargassum* sp. and *Padina australis*). Colonies of the reef-building scleractinian corals *Acropora cytherea*, *A. hyacinthus*, *A. robusta*, *Pocillopora verrucosa*, and *Platygyra lamellina* spread out to the subtidal zone. The other inhabitants of the lower intertidal subzone of Tien Sa Peninsula include the sponge *Amphimedon* sp., the barnacle *Chthamalus malayensis*, the amphipods *Ampithoe* and *Maera*, the brachyuran crabs *Leptodius exaratus*, *Actaeodes tomentosus*, *Tetralia glaberrima*, *Trapezia areolata*, and *Domecia hispida*, the chitons *Cryptoplax* sp. and *Notoplax* sp., the gastropods *Trochus maculatus* and *Polia undosa*, the sea cucumbers *Holothuria* (*Halodeima*) *atra* and *H. (Semperothuria) cinerascens*, the brittle star *Ophiactis savignyi*, and other groups of invertebrates.

On Gio Islet, the macrobenthic population is generally similar to that of Tien Sa Peninsula. Apart from the algae listed above, the lower intertidal subzone of Gio Islet is inhabited by the red algae *Ceratodictyon scoparium* and *Lithothamnion* sp., the brown alga *Dictyota implexa*, and the green algae *Dictyosphaeria versluysii* and *Neomeris annulata*. The total algal biomass is about 2 kgWW m⁻², mainly due to development of the green alga *Dictyosphaeria cavernosa* with a projective cover of bottom reaching 100%. Algae form patches 0.5–6 m² in area. Animals also include the sponge *Gelliodes* sp., the gastropods *Mauritia arabica* and *Scutus antipodes*, and the sea cucumber *Holothuria* (*Platyperona*) *difficilis*.

Blocky intertidal zone

The species composition and distribution of macrobenthic communities in the blocky intertidal zone are generally similar to the same parameters for the rocky and rocky-blocky-bouldery intertidal zones. However, the vertical stratification of the communities is on the whole less conspicuous in the blocky intertidal than in

the rocky intertidal. Even the opposite sides of the same rocky blocks at low tide are exposed to different levels of wave action, insolation, temperature, moistening, and other environmental factors. Besides, sand often accumulates between blocks and boulders and makes up a habitat with favorable conditions for infaunal species.

The blocky intertidal zone was studied only in very few sites on the southern coast of Vietnam: on Bo Tra Islet (Nam Du Archipelago), Thu and Lon islands, at Cape Dinh, in Thu and Ro bays (Table 1; Fig. 8). Communities dominated by the gastropods of the genus *Echinolittorina* and the barnacles of the genus *Chthamalus* develop occasionally, but a belt of oysters occupies a significant part of the upper intertidal subzone.

On Thu Island, only a few species of gastropods (*Echinolittorina millegrana*, *Nerita balteata*, *N. albicilla*, and *N. plicata*) may occasionally be found in the upper intertidal subzone.

At Cape Dinh, *E. millegrana* and *Chthamalus malayensis* form mixed settlements instead of separate belts. The communities are characterized by rather low biomass of animals (18.8, 5.7, and 8.5 gWW m⁻² for *E. millegrana*, *Nodilittorina pyramidalis*, and *Ch. malayensis* respectively).



Fig. 8. The rocky blocks on the south-western coast of Lon Island (Van Phong Bay). Photograph by Alexey V. Chernyshev.

In Thu Bay, a belt of the gastropod mollusk *Patelloida saccharina* and a belt of *Tetraclita* barnacles develop immediately below *Chthamalus* and above the oysters. The species composition of macrobenthic communities here is rather poor, and the total biomass of macrobenthos is quite low (in communities dominated by *Echinolittorina millegrana* and dominated by *Chthamalus malayensis* the biomass is about 45–50 gWW m⁻², and in a community dominated by *P. saccharina* – 85 gWW m⁻²).

On Lon Island, a community dominated by *Tetraclita* barnacles with the biomass of the dominant species making up 308 gWW m⁻² occurs in the upper intertidal subzone. *E. millegrana* and *Ch. malayensis* are among the prevailing species and the gastropods *Nerita albicilla* and *Scutellastra flexuosa* are also abundant in the *Tetraclita* community. In Ro Bay, macrobenthos is not found in the upper subzone.

On Thu Island, the oyster *Saccostrea scyphophilla* community with the accompanying mollusks *Perna* sp. (Bivalvia) and *Nerita albicilla* (Gastropoda) develops on rocky blocks in the middle intertidal subzone. The total biomass of macrobenthos is above 3300 gWW m⁻². A belt-forming community dominated by the brown alga *Padina boryana* occupies the lower part of the middle intertidal subzone. Other algal species include the green algae *Cladophora catenata* and *Caulerpa racemosa*, the brown algae *Dictyota dichotoma* and *Sargassum polycystum*, the red alga *Mastophora rosea*, and some others. Amphipoda, Decapoda, Gastropoda, and Polychaeta species may frequently be found in the community.

At Cape Dinh and on Lon Island, a belt of *S. scyphophilla* develops in the middle intertidal subzone and the upper part of the lower intertidal subzone. In the middle subzone, the biomass of the oyster varies from 4420 gWW m⁻² at Cape Dinh to 10600 gWW m⁻² on Lon Island. In the lower intertidal subzone, the biomass of the oyster is only 574 gWW m⁻² (Lon Island). The total biomass of macrobenthos can reach over 12 kgWW m⁻², and *S. scyphophilla* makes up to 85% of the total biomass in the community (Table 9). The barnacle *Megabalanus tintinnabulum* is also numerous among animals. The gastropods *Thylacodes* sp. and *Thalessa aculeata*, the bivalve mollusks *Barbatia cometa*, *Malleus legumen*, and *Septifer bilocularis*, the brachyuran crab *Forestiana scabra*, the polychaetes *Palola siciliensis* and *Lysidice collaris*, sponges, and amphipods are abundant groups in the *S. scyphophilla* community in the middle intertidal subzone and the upper part of the lower intertidal subzone.

In the lower part of the lower intertidal subzone, the coralline red algae *Lithophyllum* and *Lithothamnion* and diverse species of scleractinian corals are distributed forming patches at bases of blocks. At Cape Dinh, a community dominated by the brown alga *Sargassum aquifolium* with a rather rich species composition of macrobenthos develops. The total biomass of *Sargassum* is 2086 gWW m⁻².

Table 9

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the blocky intertidal zone, in the *Saccostrea scyphophilla* community (Lon Island, Van Phong Bay)

Taxa	Taxonomic group	Middle intertidal subzone		Lower intertidal subzone	
		B	N	B	N
PLANTS					
<i>Monostroma</i> sp.	Ch	–		5.9	
Total biomass of plants				5.9	
ANIMALS					
<i>Saccostrea scyphophilla</i>	Bi	10600.0	1540	574.2	20
<i>Megabalanus tintinnabulum</i>	Ci	1360.0	200	318.7	160
<i>Haliclona</i> sp.	Sp	208.5		12.0	
<i>Thylacodes</i> sp.	Ga	–	–	176.2	220
<i>Forestiana scabra</i>	De	–	–	71.6	20
<i>Barbatia cometa</i>	Bi	57.5	60	–	–
<i>Thalessa aculeata</i>	Ga	26.3	5	–	–
<i>Palola siciliensis</i>	Po	–	–	19.4	100
<i>Malleus legumen</i>	Bi	16.8	230	45.2	220
<i>Tenguella granulata</i>	Ga	15.7	15	–	–
<i>Leiosolenus levigatus</i>	Bi	11.7	235	14.8	180
<i>Arca</i> sp.	Bi	10.4	21	–	–
<i>Pachycheles stevensii</i>	De	–	–	9.6	–
<i>Anemonia</i> sp.	Ac	8.4	–	–	–
<i>Clypeomorus inflata</i>	Ga	–	–	8.4	20
<i>Platypodia alcocki</i>	De	–	–	8.2	20
<i>Septifer bilocularis</i>	Bi	7.8	275	3.9	20
<i>Isognomon australica</i>	Bi	7.6	150	–	–
<i>Tenguella musiva</i>	Ga	7.3	8	–	–
<i>Metopograpsus messor</i>	De	1.8	35	4.9	140
<i>Clibanarius ransoni</i>	De	–	–	4.8	140
<i>Leiosolenus lima</i>	Bi	3.7	12	1.3	20
<i>Actaea</i> sp.	De	–	–	3.6	20
<i>Cyclodius granulatus</i>	De	3.1	25	–	–
<i>Lysidice collaris</i>	Po	0.1	30	2.9	200
<i>Isognomon</i> sp.	Bi	2.6	10	–	–
<i>Lyncina carneola</i>	Ga	2.6	25	–	–

Table 9 (Continued)

Taxa	Taxonomic group	Middle intertidal subzone		Lower intertidal subzone	
		B	N	B	N
<i>Siphonaria</i> sp.	Ga	1.1	55	2.3	40
<i>Pseudonereis gallapagensis</i>	Po	2.0	55	1.0	20
Polyplacophora	Pol	–	–	2.0	20
<i>Drupa</i> sp.	Ga	–	–	1.4	20
<i>Irus irus</i>	Bi	1.3	60	0.8	20
<i>Pilumnopus makianus</i>	De	1.0	25	–	–
<i>Alpheus</i> sp.	De	–	–	1.0	20
<i>Perinereis cultrifera</i>	Po	0.8	25	–	–
<i>Echinolittorina millegrana</i>	Ga	0.8	30	–	–
<i>Clithon oualaniense</i>	Ga	0.7	5	–	–
Syllidae	Po	0.6	167	+	+
<i>Pinnotheres boninensis</i>	De	0.5	10	–	–
<i>Pseudonereis variegata</i>	Po	0.4	25	–	–
<i>Patelloida saccharina</i>	Ga	0.3	5	–	–
<i>Alpheus pubescens</i>	De	0.2	5	–	–
Amphipoda	Am	0.1	25	1.1	800
<i>Ceratonereis mirabilis</i>	Po	–	–	0.04	20
<i>Ophiactis savignyi</i>	Oph	–	–	0.02	20
Total biomass of animals		12361.6		1289.56	
Total biomass		12361.6		1295.36	

The surfaces of blocks, the space between them, and the underlying sand are inhabited by a rather diverse fauna: sponges (*Geodia* sp. and *Halichondria* sp.), sea anemones, sipunculid worms, polychaetes (*Lysidice collaris*, *Eunice afra*, *Perinereis nuntia brevicirris*, *Nereis* sp., and others), barnacles (*Capitulum mitella*, *Balanus* sp., and *Tetraclita* sp.), mantis shrimps (*Gonodactylus* sp. and others), hermit crabs (*Calcinus laevimanus* and *Clibanarius virescens*), brachyuran crabs (*Eriphia smithii*, *Ocypode kuhlii*, *Leptodius exaratus*, *Tetralia glaberrima*, *Grapsus longitarsis*, and others), sea urchins (*Echinometra mathaei* and others), sea cucumbers (*Stichopus chloronotus*, *Chiridota rigida*, *Holothuria* (*Halodeima*) *atra*, and *Polycheira rufescens*), brittle stars (*Ophiocoma erinaceus* and others), and sea stars (*Linckia laevigata* and others). Mollusca is the most diverse group of invertebrates in the *Sargassum* beds. It contains the chiton *Cryptoplax larvaeformis*, gastropods (*Cellana testudinaria*, *C. toreuma*, *Scutus unguis*, *Trochus maculatus*, *Nerita albicilla*, *N. costata*, *N. plicata*,

N. polita, *Planaxis sulcatus*, *Echinolittorina millegrana*, *Monetaria annulus*, *Cypraea* spp., *Ovula ovum*, *Cantharus* sp., *Tenguella musiva*, *T. granulata*, *Drupa morum*, *D. rubusidaeus*, *D. ricinus*, *Drupella margariticola*, *D. cornus*, *Purpura persica*, *Thalessa aculeata*, *Mancinella echinata*, *M. alouina*, *Reishia luteostoma*, *Mitra ambigua*, *Conus ebraeus*, *C. miles*, and *Aplysia* sp.), and bivalves (*Barbatia virescens*, *B. amygdalumtosum*, *Pinctada imbricata fucata*, *P. radiata*, *Cardita variegata*, *Leiosolenus malaccanus*, *Isognomon isognomum*, *I. perna*, *Atactodea striata*, *Arca ventricosa*, *Malleus legumen*, *Gastrochaena cuneiformis*, *Tridacna maxima*, *Spondylus tenuispinosus*, *S. lamarckii*, *Atrina strangei*, and *Mesodesma* sp.).

On Thu Island, the green algae *Ulva reticulata*, *Caulerpa racemosa*, *C. serrulata*, and *C. taxifolia*, the brown algae *Sargassum polycystum*, *S. ilicifolium*, *Padina australis*, and *Dictyota implexa*, and many others grow in a patchy pattern in the lower intertidal subzone. The total algal biomass is above 1780 gWW m⁻² (up to 99% of the total macrobenthic biomass). The same groups of invertebrates as in the middle intertidal subzone are found here. The most numerous among gastropods are *Nerita plicata*, *Monetaria moneta*, and *Pictocolumbella ocellata*.

Bouldery intertidal zone

The bouldery type of the intertidal zone was studied in the Gulf of Thailand (Gian Islet, Nam Du Archipelago), from the coastal area southeast of Nha Trang to Ro Bay (Mot Island, Me (Ben Goi Bay), Sang (Co Co Strait), and Nua islets), as well as on the west coast of the Gulf of Tonkin (Con Lo Beach) (Table 1). The vertical distribution of belt-forming communities of the bouldery intertidal zone has almost the same general pattern as in the rocky-blocky-bouldery intertidal zones. However, in the *Nodilittorina* belts gastropods belonging to the family Neritidae often dominate, together with species of the gastropod family Littorinidae. Besides, there is a decrease in the biomass of dominant species in the belt-forming communities of oysters and barnacles, whereas the biodiversity of macrobenthos is higher in all communities including the belt-forming communities of the littorinid and neritid species. Various groups of invertebrates inhabit the bouldery intertidal zone due to large number of sheltered and moisturized refuges among boulders. The macrobenthos of the southern locations and the sites of the Gulf of Tonkin has many mutual species.

The upper intertidal subzone is inhabited by a greater number of species of gastropods (*Echinolittorina millegrana*, *Nodilittorina pyramidalis*, *Nerita chamaeleon*, *N. undata*, *N. albicilla*, *N. insculpta*, *N. balteata*, *Turritella bacillum*, *Siphonaria* spp., *Patelloida saccharina*, *Monodonta labio*, *Planaxis sulcatus*, *Cel-lana toreuma*, *Clypeomorus bifasciata*, *C. batillariaeformis*, *Batillaria sordida*, *Drupella*

margariticola, *Tenguella granulata*, *Reishia clavigera*, *R. luteostoma*, and many others) (Fig. 9). Settlements of oysters *Saccostrea cucullata* (in the Gulf of Thailand), *Saccostrea scyphophilla* (from Nha Trang to Ro Bay) or *Saccostrea echinata* (in the Gulf of Tonkin) may also be found in the upper intertidal subzone. Communities dominated by the gastropods *Nerita polita* and *Clypeomorus batillariaeformis* are sometimes situated below the belt of littorinids.

On Con Lo Beach, *Aegiceras corniculatum* mangrove shrubs develop in the supratidal zone and the upper intertidal subzone. The mangrove jingle shell *Enigmonia aenigmatica* is usually found attached to the leaves or branches of *Aegiceras*. The mangrove community hosts many motile animals: brachyuran crabs (*Leptodius exaratus*, *Parasesarma pictum*, *Gaetice depressus*, *Metopograpsus thukuhar*, *Hemigrapsus sanguineus*, and others), hermit crabs, and shrimps, which are also distributed in the middle and even in the lower intertidal subzones. The intertidal barnacle *Chthamalus challengerii* is a common species on Con Lo Beach (Gurjanova, Chang Hiu Phuong, 1972).

In the upper part of the middle intertidal subzone, settlements of the barnacle *Chthamalus malayensis* develop on the tops of boulders. The bivalves *Barbatia cometa* and *Isognomon perna* also live in this subzone on Mot Island, Me, Sang, and Nua islets. The gastropod *Cellana* sp., rare Amphipoda, and the red alga *Hypnea aspera* occur on Gian Islet. *Amphibalanus amphitrite* settlements may be found on Con Lo Beach (Gurjanova, Chang Hiu Phuong, 1972).

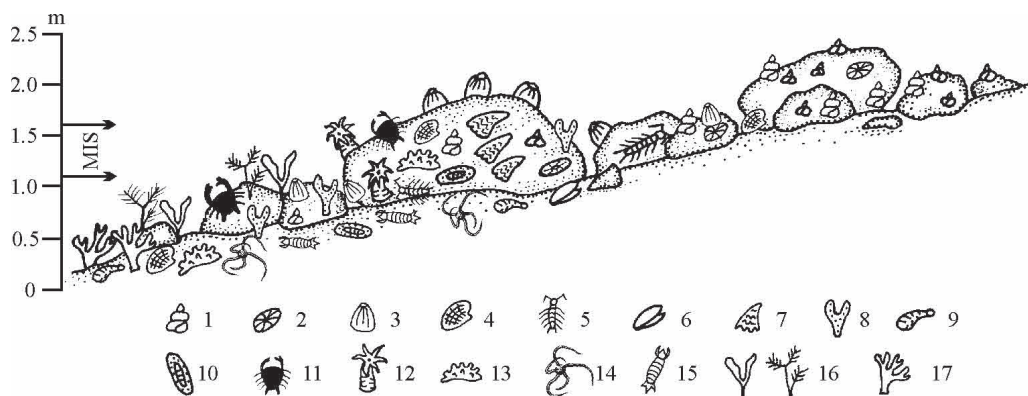


Fig. 9. Scheme of distribution of macrobenthos in the bouldery intertidal zone (from Nha Trang to Ro Bay). 1 – Gastropoda (mainly Littorinidae+Neritidae), 2 – Patellogastropoda, 3 – Cirripedia, 4 – Bivalvia, 5 – Isopoda, 6 – *Capitulum mitella*, 7 – *Saccostrea scyphophilla*, 8 – Spongia, 9 – Sipuncula, 10 – Polyplacophora, 11 – Decapoda, 12 – Actinaria, 13 – Holothuroidea, 14 – Ophiuroidea, 15 – Stomatopoda, 16 – algae, 17 – Scleractinia. Vertical scale – range over depths 0. MIS – the middle intertidal subzone.

A belt of oyster *Saccostrea scyphophilla* occupies the lower part of the middle intertidal subzone and the upper part of the lower intertidal subzone on Mot Island, Me, Sang, and Nua islets. The fauna of this community is very abundant and diverse: there are some species of sponges, sea anemones, sipunculid worms, the barnacles *Capitulum mitella* and *Tetracrita porosa*, the mantis shrimp *Gonodactylus* sp., the isopod *Dynamenopsis* sp., the shrimp *Alpheus* sp., the brachyuran crabs *Actaeodes tomentosus*, *Novactaea modesta*, *Heteropanope glabra*, *Pilumnopus makianus*, *Xanthodius* sp., *Criocarcinus superciliosus*, *Grapsus longitarsis*, *Plagusia squamosa*, *Perceon planissimum*, *Epixanthus corrosus*, *E. frontalis*, and *Nanosesarma minutum*, the porcelain crab *Petrolisthes* sp., some species of hermit crabs, chitons, the gastropods *Cellana testudinaria*, *C. toreuma*, *Nerita polita*, *N. albicilla*, *N. undata*, *Littoraria scabra*, *Luria isabella*, *Echinolittorina millegrana*, *Nodilittorina pyramidalis*, *Planaxis sulcatus*, *Monodonta labio*, *Clypeomorus batillariaeformis*, *C. pellucida*, *Mastonia rubra*, *Mauritia arabica*, *Peristernia nassatula*, *Vasum turbinellus*, *Thalessa aculeata*, *Tenguella musiva*, *T. granulata*, *Morula anaxares*, *Drupella margariticola*, *Nassa* sp., *Mitra* sp., *Conus coronatus*, *C. capitaneus*, *Clanculus* sp., and *Siphonaria* sp., the bivalves *Barbatia foliata*, *B. cometa*, *Arca ventricosa*, *Modiolus auriculatus*, *Isognomon isognomum*, *I. perna*, *I. nucleus*, *I. australica*, *Saccostrea scyphophilla*, *Cardita variegata*, *Septifer bilocularis*, *Leiosolenus malaccanus*, *L. levigatus*, *L. lima*, *Atactodea striata*, *Chama pacifica*, and *Malleus legumen*, the brittle stars *Ophiocoma erinaceus* and *O. scolopendrina*, and the sea cucumbers *Stichopus horrens*, *Holothuria* (*Semperothuria*) *cinerascens*, and *Holothuria* sp. The animal biomass is about 4400 gWW m⁻² in the oyster community, and oysters make up more than 97% of the total biomass. A belt-formig community dominated by the barnacle *Tetracrita porosa* develops immediately below the community dominated by oysters.

The lower part of the lower intertidal subzone is inhabited by communities of corals or algal communities, in which corals do not develop. The scattered thickets of the brown alga *Padina* may be found usually below oysters and *T. porosa*. Communities dominated by *Sargassum polycystum* and *S. congkinhii* also develop in the bouldery intertidal zone. There are many different species of algae (the brown algae *Dictyota implexa*, *Padina* sp., and *Turbinaria ornata*, the red alga *Laurencia tropica*, and the green algae *Halimeda opuntia*, *H. discoidea*, *Caulerpa serrulata*, and *C. racemosa*) in the communities. Besides corals and animals of the oyster belt, the brachyuran crab *Leptodius exaratus*, the gastropod *Monetaria annulus*, and the sponge *Callyspongia* (*Callyspongia*) *monilata* are frequently found in the *Sargassum* beds.

On Con Lo Beach, many other species inhabit the lower intertidal subzone (the gastropods *Lottia pelta*, *Lunella coronata*, *Clypeomorus batillariaeformis*, *Rhinoclavis sinensis*, *Murex* sp., *Nerita balteata*, *Chlorostoma xanthostigma*, *Muricodrupa fiscella*, *Nassarius pullus*, *N. hirtus*, *Nassarius* sp., *Batillaria australis*, *Eriphia smithii*,

Trochus maculatus, *Haliotis diversicolor*, *H. ovina*, and others; the bivalve mollusk *Venerupis variegata*, barnacle *Capitulum mitella*, the sea cucumbers *Holothuria* (*Mertensiothuria*) *leucospilota* and *Polychaeta rufescens*, the sea urchins *Echinometra mathaei*, *Temnopleurus toreumaticus*, and *Diadema setosum*, and other invertebrates) (Gurjanova, Chang Hiu Phuong, 1972).

Pebbly beaches

The pebbly beaches were studied on Mieu, Lon, and Ong islands (Table 1). The species composition of macrobenthos is quite poor at these sites. In the upper intertidal subzone, a community dominated by the gastropod *Supplanaxis niger* develops. Besides the dominant species, the isopod *Ligia exotica*, the brachyuran crabs *Epixanthus* spp. and *Cyclograpsus intermedius*, amphipods and turbellarians may be found. The total biomass of macrobenthos reaches 170 gWW m⁻², and *S. niger* makes up to 90% of the total biomass.

In the middle intertidal subzone and the upper part of the lower subzone, a community of the gastropod species Cerithiidae+*Nerita* spp. occurs. The total biomass of macrobenthos is about 350 gWW m⁻². *Clypeomorus batillariaeformis*, *Cerithium trailii* (Cerithiidae), and *Nerita albicilla*, *N. polita*, *N. undata*, *N. chamaeleon* (Neritidae) often occur. The barnacle *Capitulum mitella*, the brachyuran crab *Thalamita danae*, the hermit crabs *Clibanarius cruentatus* and *C. merguensis*, the gastropods *Cellana testudinaria* and *Reishia luteostoma*, the bivalves *Isognomon nucleus*, *Modiolus auriculatus*, *Barbatia fusca*, and *Saccostrea scyphophilla* are also found on the pebbly beaches.

Artificial substrata

On Tam Island (Table 1), the *Saccostrea scyphophilla* community is found on the bottoms and sides of old barges abandoned on the shore and immersed in the water. The total animal biomass can reach 10 kgWW m⁻² on the bottoms of the barges, and the oyster makes up about 93% of the total biomass of macrobenthos in the community. Various sponges and other bivalve mollusks (*Barbatia cometa*, *B. foliata*, *Arca navicularis*, *Isognomon australica*, *Isognomon* spp., *Modiolus auriculatus*, *Septifer bilocularis*, *Leiosolenus levigatus*, *L. malaccanus*, and *Coralliophaga* sp.) also cover the bottoms of the barges. The gastropods *Thalessa aculeata*, *Tenguella granulata*, and *T. musiva* are the second by biomass (up to 480 gWWm⁻²) after *Bivalvia* in the *S. scyphophilla* community. The barnacle *Megabalanus tintinnabulum* and several species of Polychaeta, Actiniaria, and Decapoda frequently occur in the upper parts of the sides of the barges.

Intertidal zone of mixed substrata

Bouldery intertidal zone with underlying sand

The bouldery intertidal zone with underlying sand is studied from the coastal area southeast of Nha Trang to Ro Bay in many locations (Tam, Mieu, Tre (Gieng Da Bay and the northern part of island), Lon (Tre Bay), and Ong islands, Hon Khoi Peninsula, Me and Ke (Ben Goi Bay), Sang (Co Co Strait), Nua, and Nu islets, Mon and Cai Ban bays, and Lon Strait), as well as in the Gulf of Thailand (Nam Du Islet, Nam Du Archipelago) (Table 1; Fig. 10). It is a gently sloping shoreline 15–50 m wide. Wave action is generally weak. Topographical dissection creates refugia for many motile forms. Infauna is especially well developed and its biomass exceeds one of the epifauna by four times. The species composition of macrobenthos is diverse, which is also typical for the bouldery intertidal zone, but the species richness increases due to abundance of infaunal invertebrates and epifaunal species living in protected or concealed microhabitats. Numerous species of gastropods, mantis shrimps, some species of polychaetes, and other inhabitants refuge under boulders and in tide pools. Sea cucumbers with fairly large body size frequently occur on the sand among boulders. The vertical distribution of the communities exhibits insignificant stratification, and patchy distribution of macrobenthos is typical for this intertidal zone. Besides, most part of the lower intertidal subzone is composed of sand with separate boulders. Therefore, there is no belt of corals (only small colonies are found on some boulders), and the belt of algae is as a rule very poorly developed. Mangrove vegetation develops in the upper intertidal subzone of some islands.

On Nam Du Islet, the macrobenthos of the upper intertidal subzone is impoverished as compared to the other subzones, but has the highest biomass (about 1890 gWW m⁻²). Most species, such as the gastropod mollusks *Planaxis sulcatus*, *Supplanaxis niger*, *Nerita balteata*, *N. albicilla*, *Monodonta labio*, *Cellana toreuma*, *C. testudinaria*, and many others, as well as decapods live under boulders. A belt-forming community of the oyster *Saccostrea scyphophilla* (above 1225 gWW m⁻²) sometimes develops on the largest rocky blocks. Macrophytic algae are absent.

The middle intertidal subzone is dominated by the same species of gastropods as in the upper intertidal subzone, with the biomass about 375 gWW m⁻². The total biomass of macrobenthos is above 1300 gWW m⁻². Distinct belts of the dominant species are commonly absent. Settlements of the crustose brown alga *Neoralfsia expansa* are observed nearly everywhere in the upper part of the subzone.



Fig. 10. The bouldery intertidal zone with underlying sand in Lon Strait (Van Phong Bay, 1 km southward of Cape Co Co). **A** – the general view, **B** – the middle intertidal subzone. Photograph by Alexey V. Chernyshev.

A community of low-growing species of algae develops from the lower part of the middle intertidal subzone to the lower intertidal subzone on Nam Du Islet. This community is formed by the red algae *Gelidiella* sp., *Gelidium pusillum*, *Centroceras clavulatum*, *Hypnea esperi*, *Polysiphonia* sp., crustose Corallinaceae species, the brown algae *Lobophora variegata* and *Neoralsia expansa*, and some others. Patches of large specimens of algae (the brown alga *Turbinaria ornata* and the red alga *Laurencia obtusa*) are occasionally found in the lower part of the middle subzone and in the lower intertidal subzone. Gastropoda, Decapoda, and Polychaeta species dominate among animals in the lower intertidal subzone.

Belt-forming communities dominated by the gastropod *Echinolittorina milligrana* and the barnacle *Chthamalus malayensis* occupy the upper intertidal subzone from Nha Trang to Ro Bay. The biomass of *Ch. malayensis* can reach about 6 kgWW m⁻² (Tre Bay in Lon Island). Sometimes rare patches of the brown alga *N. expansa* occur in these communities. Settlements of the gastropod *Supplanaxis niger* are found from the upper to the middle intertidal subzone in Gieng Da Bay of Tre Island (Tran-ngoc Loi, 1967).

A broad belt of the oyster *Saccostrea scyphophilla*, often together with the barnacle *Megabalanus tintinnabulum*, develops on boulders in the middle intertidal subzone. The biomass of the oyster varies from 1750 to 2550 gWW m⁻², and the density is 188–240 ind. m⁻² in different areas. In Gieng Da Bay, the mollusks *Nerita albicilla* (Gastropoda), *Isognomon perna* and *Saccostrea cucullata* (Bivalvia) form belts which spread to the lower intertidal subzone (Tran-ngoc Loi, 1967).

In the upper part of the lower intertidal subzone, the biomass of *S. scyphophilla* decreases, but the role of accompanying fauna increases due to development of various gastropods, holothurians, sponges, brittle stars, and decapods in the community (Table 10). In addition to quantitatively recorded species, there is a great biodiversity of intertidal animals under boulders, between them, and on sandy "islets" (coral polyps of the orders Zoantharia and Actiniaria, flatworms of the class Turbellaria, sipunculid worms, the polychaetes *Perinereis vancaurica*, *P. nuntia*, *Pseudonereis gallapagensis*, *Glycera capitata*, *Bhawania goodei*, and *Spirobranchus giganteus*, the barnacle *Tetraclita porosa*, crustaceans of the order Tanaidacea, the isopod *Cymodoce longistylis*, the brachyuran crabs *Macromedaeus nudipes*, the hermit crabs *Dardanus megistos*, *Clibanarius virescens*, and *C. eurysternus*, chitons, the gastropods *Scutellastra flexuosa*, *Cellana testudinaria*, *Patelloida saccharina*, *Turbo bruneus*, *Nerita costata*, *N. chamaeleon*, *Planaxis sulcatus*, *Clypeomorus batillariaeformis*, *C. irrorata*, *Pictocolumbella ocellata*, *Polia undosa*, *Morula aspera*, *Tenguella granulata*, *Sabia conica*, *Mitra litterata*, *Conus chaldaeus*, *Chicoreus brunneus*, *Mauritia arabica*, *Siphonaria* sp., *Bulla* sp., and *Aplysia* sp., the bivalves *Barbatia foliata*, *B. cometa*, *Striarca symmetrica*, *Leiosolenus malaccanus*, *Lithophaga caperata*, *Isognomon isognomum*, *I. perna*, *Septifer*

Table 10

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos
in the low intertidal subzone of the bouldery intertidal zone with underlying sand,
in the *Saccostrea scyphophilla* community (Ben Goi and Ro bays)

Taxa	Taxonomic group	B	N
PLANTS			
<i>Cladophora laetevirens</i>	Ch	59.0	
<i>Herposiphonia secunda</i> var. <i>tenella</i>	Rh	5.9	
<i>Mastophora pacifica</i>	Rh	0.1	
Total biomass of plants		65.0	
ANIMALS			
<i>Saccostrea scyphophilla</i>	Bi	501.5	38
Holothuroidea	Ho	64.0	35
<i>Nerita polita</i>	Ga	33.3	46
<i>Callyspongia</i> (<i>Callyspongia</i>) <i>monilata</i>	Sp	28.9	
<i>Ophiocoma scolopendrina</i>	Oph	9.1	2
<i>Drupa</i> sp.	Ga	8.6	11
<i>Conus coronatus</i>	Ga	6.4	2
<i>Nerita albicilla</i>	Ga	5.6	8
<i>Pilumnus vesperilio</i>	De	3.1	2
<i>Tenguella musiva</i>	Ga	2.6	3
<i>Monetaria annulus</i>	Ga	2.0	2
<i>Mitrella scripta</i>	Ga	1.4	5
<i>Clibanarius merguiensis</i>	De	1.2	6
<i>Drupella margariticola</i>	Ga	1.1	3
<i>Percnon planissimum</i>	De	1.1	2
<i>Leptodius exaratus</i>	De	0.3	3
<i>Modiolus auriculatus</i>	Bi	0.3	3
<i>Nicolea venustula</i>	Po	0.2	35
<i>Arca ventricosa</i>	Bi	0.2	2
<i>Nassarius</i> sp.	Ga	0.2	2
<i>Perinereis cultrifera</i>	Po	0.1	—
Amphipoda	Am	0.1	—
<i>Thalamita prymna</i>	De	0.1	—
Paguridae	De	0.05	2
<i>Ceratonereis mirabilis</i>	Po	0.04	5

Table 10 (Continued)

Taxa	Taxonomic group	B	N
<i>Platynereis dumerilii</i>	Po	0.03	6
<i>Eurythoe complanata</i>	Po	0.02	2
<i>Cerithium</i> sp.	Ga	0.01	2
<i>Haliscarcinus orientalis</i>	De	0.01	2
Total biomass of animals		672.21	
Total biomass		737.26	

excisus, *Cardita variegata*, *Malleus legumen*, *Coralliophaga* sp., *Pinctada maculata*, *Brachidontes setiger*, *Asaphis violascens*, *Gafrarium pectinatum*, *Gastrochaena cuneiformis*, *Jouannetia cumingii*, *Chama pacifica* and *Ch. dunkeri*, the brittle stars *Ophiopsis cincta* and *Ophiocoma erinaceus*, and fishes). On Lon Island, the total animal biomass is 1160 gWW m⁻² under boulders at the level of the *S. scyphophilla* belt. On Tam Island, the total animal biomass is 150 gWW m⁻². On Nua Islet, the brittle star *O. erinaceus* makes up to 90% of the total animal biomass.

In the lower part of the lower intertidal subzone, there are diverse algae immediately below the *S. scyphophilla* belt. On Lon Island, the biomass of the brown alga *Padina australis* is up to 750 gWW m⁻². Other algae here include the brown algae *Dictyota friabilis* and *Sphacelaria rigidula*, the red algae *Chondria repens*, *Centroceras clavulatum*, *Herposiphonia secunda* var. *tenella*, *Mastophora pacifica*, and *Gayliella flaccida*, and the green alga *Cladophora laetevirens*. Apart from the animals listed for the upper part of the subzone, the lower part of the subzone is also inhabited by diverse gastropods (*Monodonta labio*, *Nerita polita*, *N. undata*, *Clypeomorus pellucida*, *C. petrosa chemnitziana*, *Erronea erronea*, and *Mitrella scripta*), polychaetes (*Lumbri-neris heteropoda*, *Nicolea venustula*, and *Platynereis dumerilii*), decapods (*Haliscarcinus orientalis*, *Leptodius exaratus*, *Macromedaeus quinque- dentatus*, *Epixanthus frontalis*, *Eriphia smithii*, *Thalamita crenata*, *Grapsus tenuicrustatus*, and *Calcinus laevimanus*), bivalves (*Chama croceata* and *Isognomon legumen*), and the brittle star *Ophiocoma scolopendrina*. On Lon Island, the total animal biomass is up to 400 gWW m⁻² on boulders, and the gastropods *M. labio* and *Clypeomorus batillariaeformis* are dominant species. On Nua Islet, the total animal biomass is 165 gWW m⁻² on the sand, and *O. scolopendrina* makes up above 70% of the animal biomass. In Cai Ban Bay, the belt of the brown algae *Padina australis*+*Sargassum polycystum*+*Sargassum congkinhii* develops. There are also the red alga *Laurencia tropica*, the brown algae *Dictyota implexa* and *Turbinaria ornata*, the green algae *Halimeda opuntia*, *H. discoidea*, *Caulerpa serrulata*, and *C. racemosa*.

On Ke Islet (Ben Goi Bay), the intertidal zone is up to 30 m wide. The upper intertidal subzone is composed of sand, and occupied by rather sparse thickets of *Avicennia* sp. and *Rhizophora* sp. mangrove trees. The mangroves reach 70–200 cm in height. The mangrove periwinkle *Littoraria scabra* commonly occurs on the seaward edge of the mangrove trunks, at 1–1.5 m above the bottom. Inhabitants of sandy beaches also include the polychaetes *Perinereis cultrifera* and *Bhawania goodei*, the shrimp *Alpheus strenuus strenuus*, the small brachyuran crab *Epixanthus frontalis*, some amphipod species, the gastropods *Nerita polita*, *Planaxis sulcatus*, *Clypeomorus irrorata*, and *Morula anaxares*, the bivalve mollusk *Asaphis violascens*, and the sea cucumbers of the family Synaptidae. The total animal biomass is about 50 gWW m⁻².

Just below the mangrove thickets, there is a sandy gently sloping tidal flat about 30 m wide at low tide. Boulders (10–20 cm diameter) lie scattered on the underlying sand. In the upper and middle intertidal subzones, numerous burrows of the hermit crab *Coenobita* sp. (from 5 to 15 ind. m⁻²) are found in the sand.

The tidal flat may appear lifeless at low tide; only a distinct belt of oyster *Saccostrea scyphophilla* can be seen on the boundary of the middle and lower intertidal subzones. Actually, this intertidal site is inhabited by diverse groups of animals which tend to burrow into soft substratum or to hide under boulders (sipunculid worms, the polychaetes *P. cultrifera* and *Ceratonereis mirabilis*, the mantis shrimp *Gonodactylus chiragra*, the shrimp *Alpheus* sp., the porcelain crab *Petrolisthes asiaticus*, the brachyuran crabs *Epixanthus frontalis*, *Leptodius exaratus*, *Uca* (*Tubuca*) *urvillei*, and *Pilumnus vespertilio*, the gastropod *Nerita polita*, the bivalve mollusk *Asaphis violascens*, the brittle star *Ophiocoma scolopendrina*, and the sea cucumber *Holothuria* sp.). The total animal biomass is about 6600 gWW m⁻² on boulders, and oysters make up to 99% of the biomass. Under boulders, the total animal biomass is 1160 gWW m⁻², and *A. violascens* makes up about 84% of the biomass.

In the lower intertidal subzone, large aggregations of the sea urchin *Diadema setosum* may be found at the water's edge. Animals living under boulders and members of sand-dwelling infauna are very diverse. Besides the animals listed for the boundary between the middle and lower intertidal subzones, this subzone includes the sponge *Gelliodes fibulata*, the polychaete *Thelepus plagiotoma*, chitons, the gastropods *Haliotis asinina*, *Cellana toreuma*, *Nerita albicilla*, *N. chamaeleon*, *Trochus maculatus*, *Monetaria annulus*, *Scutus unguis*, *Cantharus* sp., *Nassarius graphiterus*, *Drupella margariticola*, *Tenguella musiva*, *Mitra scutulata*, *Conus coronatus*, *C. musicus*, *Siphonaria atra*, and nudibranchs, the bivalve mollusks *Isognomon perna*, *I. isognomum*, *Saccostrea scyphophilla*, *Arca ventricosa*, *Barbatia cometa*, *B. amygdalumtostum*, *Atrina strangei*, *A. vexillum*, *Pinctada radiata*, *Cardita variegata*, *Modiolus auriculatus*, *Septifer bilocularis*, *Gafrarium divaricatum*, and *Venus* sp.,

the sea star *Echinaster luzonicus*, the sea cucumbers *Holothuria* (*Halodeima*) *atra*, *Chiridota rigida*, and *Holothuria* spp. The blennioid fishes of the genus *Salarias* are often found living on the sandy bottom or in empty shells. The moray eels *Echidna nebulosa* and *Gymnothorax pictus* occur among boulders and sometimes in tide pools. The gobiid fishes inhabit the lower intertidal subzone of Ke Islet at the water's edge.

Intertidal zone of dead coral reefs

The intertidal zone of dead coral reefs was found in many places from Cape Dinh on the south to Re Island on the north (Table 1). This type of the intertidal zone is usually represented by gently sloping coasts exposed to weak wave action. The intertidal zone is up to a few hundred meters wide. The plateau of a dead coral reef covered with sand (often with admixture of silt) with rare boulders is generally situated in the middle and lower subzones. In the upper intertidal subzone, a reef is covered with clean coarse sand with coral rubble and pieces of mollusk shells. This beach may have quite a steep slope (25–30°). Communities are generally characterized by patchy distribution and rarely have distinct dominant species. The mixed type of bottom deposits, dissected microrelief, and the presence of tide pools, burrows, cracks, and holes in a dead coral reef creates favorable conditions for the development of diverse macrobenthos, particularly cryptofauna (including fairly large Stomatopoda, Isopoda, Caridea, Polychaeta, Gastropoda, Bivalvia, various coral reef fishes, fishes of Muraenidae, and even sea snakes). In some silted bays protected from wave action, mangroves can develop. Settlements of *Littoraria scabra* may be found on stems and branches of mangrove trees.

On Re Island, the intertidal zone of dead coral reef in a sheltered lagoon is about 1 km wide. The plateau is covered with silted sand with rare boulders (Fig. 11). Communities are characterized by patchy distribution.

In the upper intertidal subzone, a *Saccostrea scyphophilla* community with the total biomass of macrobenthos up to 3500 gWW m⁻² is found on hard substrata (Fig. 12; Table 11). The sponge *Suberites* sp. and the gastropods *Nerita plicata* and *N. insculpta* prevail on boulders. Colonies of the coral polyp *Zoanthus* sp. inhabit patches of sand accumulation between boulders. Algae are absent; however, the animal species composition is rather diverse in the upper subzone. In addition to quantitatively recorded species, the sponge *Callyspongia* sp., the isopods *Ligia* sp. and *Dynamenella trachydermata*, the brachyuran crabs *Calappa hepatica*, *Thalamita admete*, and others, numerous species of gastropods (*Nerita albicilla*, *Conus ebraeus*, *Monetaria annulus*, *M. moneta*, *Polia fumosa*, *Drupella margariticola*, and others), bivalve mollusks *Atrina pectinata* and *Perna serratula*, the brittle star *Ophiocoma* (*Breviturma*) *brevipes*, the quite large sea cucumbers *Synapta maculata* and *Holothuria* (*Mertensiothuria*) *leucopilota* frequently occur on dead corals.



Fig. 11. The intertidal zone of dead coral reef in the lagoon of Re Island.

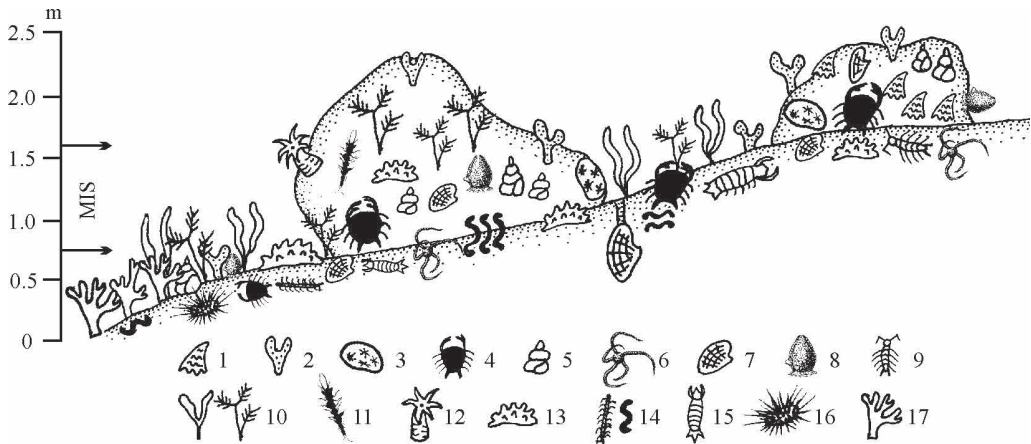


Fig. 12. Scheme of distribution of macrobenthos in the intertidal zone of dead coral reef (Re Island). 1 – *Saccostrea scyphophilla*, 2 – *Spongia*, 3 – *Zoantharia*, 4 – *Decapoda*, 5 – *Gastropoda*, 6 – *Ophiuroidea*, 7 – *Bivalvia*, 8 – *Ascidiacea*, 9 – *Isopoda*, 10 – algae and seagrasses, 11 – *Tanaidacea*, 12 – *Actinaria*, 13 – *Holothuroidea*, 14 – *Polychaeta*, 15 – *Stomatopoda*, 16 – *Echinoidea*, 17 – *Scleractinia*. Vertical scale – range over depths 0. MIS – the middle intertidal subzone.

Table 11

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos
in intertidal zone of dead coral reef (Re Island)

Taxa	Taxonomic group	Upper intertidal subzone		Middle intertidal subzone		Lower intertidal subzone
		B	N	B	N	
PLANTS						
<i>Thalassia hemprichii</i>	Tra	–		1787.5		+
Total biomass of plants				1787.5		
ANIMALS						
<i>Saccostrea scyphophilla</i>	Bi	2000.0	283	–	–	–
<i>Suberites</i> sp.	Sp	793.4		1545.0		+
<i>Holothuria (Halodeima) atra</i>	Ho	–	–	1050.0	25	+
<i>Zoanthus</i> sp.	Zo	333.3	667	58.5	265	–
Paguridae	De	0.3	3	322.7	565	+
<i>Nerita plicata</i>	Ga	112.9	42	–	–	–
<i>Ophiocoma (Breviturma) dentata</i>	Oph	–	–	96.5	15	–
<i>Nerita insculpta</i>	Ga	75.7	247	–	–	+
Stomatopoda	St	–	–	49.8	40	–
<i>Clypeomorus bifasciata</i>	Ga	44.7	307	3.8	5	+
<i>Planaxis sulcatus</i>	Ga	34.2	46	–	–	–
<i>Pinctada margaritifera</i>	Bi	+	+	32.0	5	+
<i>Tenguella granulata</i>	Ga	–	–	30.5	15	+
<i>Pilumnus vesperilio</i>	De	–	–	17.5	5	–
<i>Echinolittorina millegrana</i>	Ga	12.1	58	–	–	–
<i>Ophiocoma scolopendrina</i>	Oph	11.7	3	–	–	–
<i>Cerithium columna</i>	Ga	10.1	41	–	–	–
<i>Leiosolenus levigatus</i>	Bi	–	–	9.5	15	+
<i>Polia undosa</i>	Ga	9.2	7	–	–	–
<i>Eupilumnus actumnoides</i>	De	–	–	7.2	15	–
<i>Leptodius exaratus</i>	De	–	–	3.5	15	–
Asciadiacea	Asc	3.5		2.3		+
<i>Alpheus</i> sp.	De	+	+	2.8	95	+
<i>Cirratus cirratus</i>	Po	–	–	1.8	75	+
Decapoda	De	–	–	1.7	70	–
Tanaidacea	Ta	–	–	1.3	100	–
<i>Ophiactis savignyi</i>	Oph	1.3	13	–	–	–
<i>Metopograpsus messor</i>	De	–	–	1.1	15	–

Table 11 (Continued)

Taxa	Taxonomic group	Upper intertidal subzone		Middle intertidal subzone		Lower intertidal subzone
		B	N	B	N	
<i>Perinereis cultrifera</i>	Po	–	–	0.8	100	+
<i>Ceratonereis mirabilis</i>	Po	–	–	0.6	40	+
<i>Lysidice unicornis</i>	Po	–	–	0.6	40	+
<i>Eurythoe complanata</i>	Po	–	–	0.4	5	+
<i>Gonodactylus chiragra</i>	St	–	–	0.2	5	+
<i>Palola siciliensis</i>	Po	–	–	0.1	5	–
Total biomass of animals		3442.4		3240.2		
Total biomass		3442.4		5027.7		

The middle intertidal subzone is covered with the seagrass *Thalassia hemprichii* (about 1790 gWW m⁻²). In this community, there is a rich diversity of algae (the red algae *Tricleocarpa cylindrica*, *Ceratodictyon spongiosum*, *Laurencia corymbosa*, *Lithophyllum okamurae*, *Centroceras clavulatum*, many species of *Gracilaria*, and others; the green algae *Halimeda opuntia*, *H. discoidea*, *Dictyosphaeria cavernosa*, *Ulva* sp., *Anadyomene plicata*, *Boergesenia forbesii*, many species of *Caulerpa*; the brown algae *Sargassum ilicifolium*, *S. polycystum*, and *Hormophysa cuneiformis*). The sponge *Suberites* sp. and the sea cucumber *Holothuria* (*Halodeima*) *atra* make up about 80% of the total biomass of animals. Diverse polychaetes (*Perinereis cultrifera*, *Cirratulus cirratus*, *Ceratonereis mirabilis*, *Lysidice unicornis*, and others), the coral polyp *Zoanthus* sp., hermit crabs, and shrimps dwell on the rhizomes and roots of *T. hemprichii*. The total biomass of macrobenthos is above 5 kgWW m⁻².

The plant species composition of the lower intertidal subzone is almost similar to that of the middle subzone. Algae inhabit boulders, coral rubble, and such habitats as calcareous tubes of sedentary polychaetes or live corals with the projective cover of substrate up to 70–100%. As for animals, colonies of the hard corals *Porites lobata* and *P. lutea* form extensive settlements. The large (up 50 cm in diameter) sea anemone *Gyrostoma* sp. and the sea cucumber *H. (H.) atra* are often found here. The corals and boulders are partly covered with sponges (*Suberites* sp., *Clathria* (*Thalysias*) *erecta*, *Spirastrella* sp., *Gelliodes* sp., *Amphimedon* sp., and *Raspailia* sp.) and colonial ascidians. Diverse polychaetes, brachyuran crabs (*Phymodius* sp., *Calcinus* sp., and others) and hermit crabs, gastropods (*Conus ebraeus*, *C. flavidus*, *C. lividus*, *Monetaria annulus*, *M. moneta*, *Drupella margariticola*, *Canarium mutabile*, *Mauritia arabica*, *Erosaria helvola*, and others), bivalve mollusks (*Leiosolenus levigatus* and *Pinctada margaritifera*), sea urchins, coral reef fishes and moray eels are numerous in cracks and holes of dead corals.

Southward of Re Island (from Cape Dinh to Ro Bay), the macrobenthic species composition of the communities of dead coral reefs differs from that of Re Island. At Thon Son Hai (6 km northward of Cape Dinh), the intertidal zone of dead coral reef is about 300 m wide. It is an open coast exposed to almost permanent wave action. The upper intertidal subzone here represents beaches of coarse sand. On the boundary of the upper and middle subzones, a reef flat starts, slightly sloping towards the open sea. The reef crest is exposed at low tide, and the outer edge of the reef slope steeply drops into the sea. Almost the entire plateau is covered with the sea water layer up to 10 cm deep even at low tide, and forms a giant tide pool.

In the upper intertidal subzone, macrobenthos is found only on the uppermost edge of the reef. Here a belt-forming community is developed, dominated by the gastropod *Clypeomorus batillariaeformis* and the green alga *Cladophora laetevirens* (Table 12). The red alga *Parviphycus adnatus* and the brown alga *Dictyosphaeria versluisii* also occur.

Table 12

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the lower part of the upper intertidal subzone of dead coral reef, in the *Clypeomorus batillariaeformis*+*Cladophora laetevirens* community (Thon Son Hai)

Taxa	Taxonomic group	B	N
PLANTS			
<i>Cladophora laetevirens</i>	Ch	418.0	
<i>Valonia aegagropila</i>	Ch	158.0	
<i>Palisada perforata</i>	Rh	13.7	
Total biomass of plants		589.7	
ANIMALS			
<i>Clypeomorus batillariaeformis</i>	Ga	874.0	2940
<i>Nerita albicilla</i>	Ga	13.6	80
<i>Septifer</i> sp.	Bi	3.9	40
<i>Modiola</i> sp.	Bi	1.1	80
<i>Cerithium</i> sp.	Ga	1.0	40
<i>Perinereis nigropunctata</i>	Po	0.2	20
<i>Lysidice collaris</i>	Po	0.2	20
Amphipoda	Am	0.1	100
<i>Ceratonereis mirabilis</i>	Po	0.1	40
Total biomass of animals		894.0	
Total biomass		1483.7	

A belt of the seagrass *Thalassia hemprichii*, 30 m wide, spreads along the middle intertidal subzone (Table 13). The projective cover of the bottom by *Thalassia* is about 70%. Among seagrass thickets, a wide variety of algae may be found. The red alga *Palisada perforata* and the green alga *Halimeda tuna* dominate this community among algae. As for animals, the bivalves *Anadara antiquata* and *Modiolus auriculatus* prevail. Below the belt of *Thalassia*, a community dominated by the red alga *P. perforata* and the bivalve mollusk *Chama croceata* develops (Table 14). The brittle star *Ophiocoma scolopendrina* is subdominant in the community.

Table 13

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the upper part of the middle intertidal subzone of dead coral reef, in the *Thalassia hemprichii* community (Thon Son Hai)

Taxa	Taxonomic group	B	N
PLANTS			
<i>Thalassia hemprichii</i>	Tra	2279.3	
<i>Palisada perforata</i>	Rh	145.8	
<i>Halimeda tuna</i>	Ch	142.9	
<i>Dictyosphaeria versluysii</i>	Och	72.2	
<i>Caulerpa serrulata</i>	Ch	63.0	
<i>Valonia aegagropila</i>	Ch	31.9	
<i>Spyridia filamentosa</i>	Rh	24.9	
<i>Hypnea esperi</i>	Rh	14.9	
<i>Gracilaria arcuata</i>	Rh	14.9	
<i>Chondrophycus articulatus</i>	Rh	10.8	
<i>Gelidiella acerosa</i>	Rh	0.8	
<i>Laurencia decumbens</i>	Rh	0.7	
<i>Caulerpa fastigiata</i>	Ch	0.7	
<i>Rhipidosiphon javensis</i>	Ch	0.3	
Total biomass of plants		2812.2	
ANIMALS			
<i>Anadara antiquata</i>	Bi	80.7	7
<i>Modiolus auriculatus</i>	Bi	65.3	13
<i>Conus ebraeus</i>	Ga	60.7	7
<i>Stylissa flexibilis</i>	Sp	20.9	
<i>Eurythoe complanata</i>	Po	10.0	7
<i>Callyspongia (Cladochalina) fibrosa</i>	Sp	8.0	
<i>Pilumnus rufopunctatus</i>	De	3.5	13
Amphipoda	Am	3.0	2133

Table 13 (Continued)

Taxa	Taxonomic group	B	N
<i>Codakia punctata</i>	Bi	2.5	7
<i>Gonodactylus chiragra</i>	St	1.8	13
<i>Calcinus gaimardii</i>	De	1.3	13
<i>Alpheus pacificus</i>	De	1.2	7
<i>Clathria</i> sp.	Sp	0.8	
<i>Ceratonereis mirabilis</i>	Po	0.3	33
<i>Lysidice collaris</i>	Po	0.2	13
Sipuncula	Si	0.2	40
<i>Septifer bilocularis</i>	Bi	0.1	7
<i>Leodice antennata</i>	Po	0.1	7
<i>Tellina staurella</i>	Bi	0.1	7
<i>Lysidice unicornis</i>	Po	0.1	7
Total biomass of animals		260.7	
Total biomass		3072.9	

Table 14

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the lower part of the middle intertidal subzone and the upper part of the lower intertidal subzone of dead coral reef, in the *Chama macerophylla*+*Palisada perforata* community (Thon Son Hai)

Taxa	Taxonomic group	B	N
PLANTS			
<i>Palisada perforata</i>	Rh	392.0	
<i>Chondrophycus articulatus</i>	Rh	28.1	
<i>Valonia aegagropila</i>	Ch	28.0	
<i>Hypnea esperi</i>	Rh	9.2	
<i>Anadyomene plicata</i>	Ch	0.5	
Total biomass of plants		457.8	
ANIMALS			
<i>Chama macerophylla</i>	Bi	486.0	20
<i>Ophiocoma scolopendrina</i>	Oph	224.0	40
Ascidacea	Asc	20.2	
<i>Gonodactylus chiragra</i>	St	2.7	1
Amphipoda	Am	2.1	860
<i>Ceratonereis mirabilis</i>	Po	0.1	20
Total biomass of animals		735.1	
Total biomass		1192.9	

In the upper part of the lower intertidal subzone, there is a community of mixed algae (algal mosaic). The red algae *Acrocystis nana* and *Chondrophycus articulatus* dominate the community (Table 15). A brown seaweed *Sargassum polycystum* community occupies most of the lower intertidal subzone. The polychaete *Eurythoe complanata* is a dominant species among animals (Table 16). The most numerous invertebrates are the polychaetes and amphipods. Diverse decapods (*Plagusia immaculata*, *Thalamita crenata*, *Leptodius exaratus*, *Pilumnus vesperilio*, *Chlorodiella nigra*, *Eriphia smithii*, *Alpheus* sp., and others), gastropods (*Monetaria annulus*, *M. moneta*, *Erronea erronea*, *Drupella margariticola*, *Tenguella granulata*, *Bursa granulalis*, *Mitra scutulata*, *Engina lineata*, *Cyclope neritea*, *Clypeomorus irrorata*, *Monoplex gemmatus*, *Conus ebraeus*, *C. coronatus*, and *Aplysia* sp.), bivalves (*Acar plicata*, *Isognomon perna*, *Gafrarium pectinatum*, and *Chama croceata*), echinoderms (*Echinometra*

Table 15

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the upper part of the lower intertidal subzone of dead coral reef, in the *Acrocystis nana*+*Chondrophycus articulatus* community (Thon Son Hai)

Taxa	Taxonomic group	B	N
PLANTS			
<i>Acrocystis nana</i>	Rh	107.0	
<i>Chondrophycus articulatus</i>	Rh	93.9	
<i>Hypnea esperi</i>	Rh	80.4	
<i>Sargassum polycystum</i>	Och	57.1	
<i>Gelidiella acerosa</i>	Rh	9.6	
<i>Gracilaria canaliculata</i>	Rh	2.6	
<i>Gelidium spathulatum</i>	Rh	0.8	
<i>Hydroclathrus clathratus</i>	Och	0.2	
<i>Caulerpa fastigiata</i>	Ch	0.2	
Total biomass of plants		352.4	
ANIMALS			
<i>Pinctada radiata</i>	Bi	58.7	20
<i>Nereis falcaria</i>	Po	0.4	200
<i>Haliscarcinus messor</i>	De	0.3	20
<i>Ceratonereis mirabilis</i>	Po	0.2	40
<i>Latirus</i> sp.	Ga	0.2	20
Amphipoda	Am	0.2	20
<i>Leodice antennata</i>	Po	0.1	40
Total biomass of animals		60.1	
Total biomass		412.5	

mathaei and *Ophiocoma scolopendrina*), and some other groups of invertebrates are also found in the *Sargassum* community. Small colonies of the reef-building scleractinian corals *Montipora*, *Porites*, *Goniastrea*, *Favia*, and *Isopora palifera* occur along the edge of the reef in the intertidal zone of Thon Son Hai.

Table 16

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the lower part of the lower intertidal subzone of dead coral reef, in the *Sargassum polycystum*+*Eurythoe complanata* community (Thon Son Hai)

Taxa	Taxonomic group	B	N
PLANTS			
<i>Sargassum polycystum</i>	Och	937.0	
<i>Dictyosphaeria versluysii</i>	Och	114.4	
<i>Padina australis</i>	Och	85.2	
<i>Caulerpa racemosa</i>	Ch	84.1	
<i>Caulerpa serrulata</i>	Ch	58.9	
<i>Valonia aegagropila</i>	Ch	20.7	
<i>Palisada perforata</i>	Rh	14.1	
<i>Hypnea esperi</i>	Rh	6.5	
<i>Asteromenia anastomosans</i>	Rh	5.4	
<i>Bornetella sphaerica</i>	Rh	1.9	
<i>Caulerpa fastigiata</i>	Ch	0.9	
<i>Gelidiella acerosa</i>	Rh	0.4	
<i>Caulerpa sertularioides</i>	Ch	0.2	
<i>Caulerpa taxifolia</i>	Ch	0.1	
Total biomass of plants		1329.0	
ANIMALS			
<i>Eurythoe complanata</i>	Po	146.0	60
<i>Holothuria (Halodeima) atra</i>	Ho	61.9	20
<i>Pseudosuberites lobulatus</i>	Sp	9.0	
<i>Psammis cavipes</i>	De	7.5	20
<i>Leodice antennata</i>	Po	4.2	2320
Amphipoda	Am	3.9	3600
Sipuncula	Si	2.2	40
<i>Gonodactylus chiragra</i>	St	0.8	20
<i>Lysidice unicornis</i>	Po	0.1	100
<i>Terebellides stroemii</i>	Po	0.1	20
Total biomass of animals		235.6	
Total biomass		1565.6	

From Bau Than Bay northward the brachyuran crabs *Ocypode ceratophthalmus*, *O. convexa*, and *O. cordimanus* inhabit the upper intertidal subzone of wave-exposed sandy beaches. On sandy-silted beaches with admixture of coral rubble and shells (Hon Khoi Peninsula and Hon Gom Peninsula (Nai Bay)), a community dominated by the gastropods of the family Cerithiidae (*Clypeomorus batillariae-formis* or *Strobiligera inflata*) is found. The total animal biomass of the community can reach 665 gWW m⁻². Besides the dominating gastropods, the community includes the hermit crab *Clibanarius ransonii*, the brachyuran crabs (*Thalamita crenata*, *Actaea amoyensis*, *Metopograpsus messor*, and *Uca (Austruca) annulipes*), the gastropods (*Nerita chamaeleon* and *Drupella margariticola*), the polychaete *Perinereis cultrifera*, and the bivalve mollusks (*Asaphis violascens*, *Brachidontes mutabilis*, and *Gafrarium pectinatum*). Below Cerithiidae a belt-forming community dominated by *Nerita* gastropods (*N. chamaeleon*, *N. albicilla*, and *N. balteata*)+*Planaxis sulcatus* develops. The total animal biomass is as high as 280 gWW m⁻², and diverse mollusks make up 80% of the biomass. The community comprises quite common species of gastropods (*Echinolittorina millegrana*, *Nodilittorina pyramidalis*, *Littoraria scabra*, *Natica vitellus*, *Cerithium traillii*, *Cellana toreuma*, *Supplanaxis niger*, and *Tenguella musiva*), bivalve mollusks (*Gafrarium dispar*, *Atrina strangei*, and *Atactodea striata*), polychaetes (*Lysidice unicornis* and *Marphysa mossambica*), sipunculid worms, the hermit crab *Calcinus gaimardii*, relatively small-sized crabs (*Th. crenata* and others), and occasionally nudibranchs and sea cucumbers. Patches of *Batillaria zonalis* and settlements of *Chthamalus malayensis* sometimes occur.

On the boundary between the upper and middle intertidal subzones, a community dominated by the bivalve mollusks *Anadara antiquata* and *Gafrarium pectinatum* sometimes develops instead of *Chthamalus malayensis*. The community is abundant with various bivalves (*Chama brassica*, *Saccostrea scyphophilla*, *Vasticardium elongatum enode*, and *Tellina palatum*), which make up more than 99% of the total biomass of macrobenthos (up to 1850 gWW m⁻²). Sometimes the algae *Gracilaria canaliculata*, *Hypnea esperi*, and *Cladophoropsis membranacea* may be found.

In Bau Than Bay and other areas from Cape Dinh to Ro Bay, the flora and fauna are exceptionally diverse. Communities dominated by the bivalve mollusks *Modiolus auriculatus*, *Leiosolenus levigatus*, *Gafrarium pectinatum*, and *Barbatia foliata* are typical for the middle intertidal subzone on coral plateaus covered with sand. The species composition of these communities is rather diverse, but mollusks, polychaetes, and algae basically prevail. Other bivalve mollusks are represented by rather common species (*Arca ventricosa*, *Barbatia fusca*, *B. foliata*, *B. virescens*, *Isognomon perna*, *I. isognomum*, *Chama croceata*, *Modiolus auriculatus*, *Fragum fragum*, *Leiosolenus malaccanus*, *L. lischkei*, *Tridacna maxima*, *Septifer bilocularis*, *Pinctada radiata*, *Tellina palatum*, *T. remies*, *Semele zebuensis*,

Pinna muricata, and others). The average biomass of bivalves varies between 445 and 750 gWW m⁻², but makes up to 70–80% of the total animal biomass. The communities often include diverse species of gastropods (*Turbo bruneus*, *Nerita albicilla*, *N. chamaeleon*, *N. undata*, *Monodonta labio*, *Erronea erronea*, *Clypeomorus batillariaeformis*, *C. petrosa chemnitziana*, *Cerithium traillii*, *Monoplex pilearis*, *Polia undosa*, *Pictocolumbella ocellata*, *Coralliophila monodonta*, *Conus ebraeus*, *Striarca symmetrica*, *Rhinoclavis articulata*, *Semiricinula muricina*, *Nudibranchia*, and others). *Drupella margariticola* and *Aplysia* sp. are the most numerous gastropods. Polychaetes are represented by a fairly large number of species (*Palola siciliensis*, *Perinereis cultrifera*, *P. nigropunctata*, *Spirobranchus kraussii*, *Paralepidonotus ampulliferus*, *Lepidonotus carinulatus*, *Glycera alba*, *Dasybranchus caducus*, and *Eurythoe complanata*). Algae are also diverse in the middle intertidal subzone, especially red and green algae (the red algae *Tricleocarpa cylindrica*, *Gracilaria canaliculata*, *Gelidiella lubrica*, *Gelidium spathulatum*, *Hypnea esperi*, *H. pannosa*, *Laurencia brachyclados*, and *Centroceras gasparrinii*, the green algae *Valonia aegagropila*, *Rhizoclonium grande*, *Dictyosphaeria cavernosa*, and *Cladophoropsis sundanensis*, and others). *Gonodactylus chiragra* of Stomatopoda, the brittle stars *Ophiactis savignyi* and *Ophiocoma (Breviturma) brevipes*, the starfish *Archaster typicus*, the sea cucumber *Stichopus chloronotus*, numerous brachyuran crabs (*Chlorodiella laevissima*, *Nanosesarma minutum*, *Thalamita crenata*, *Leptodius exaratus*, *Macromedaeus nudipes*, *Metopograpsus messor*, *Paractaea rufopunctata*, and *Menaethius monoceros*), porcelain crabs, and the shrimp *Alpheus lobidens* inhabit holes and cracks in coral reefs.

In the middle intertidal subzone of Hon Khoi Peninsula, a community dominated by the red alga *Palisada perforata* occurs with the total biomass of macrobenthos up to 400 gWW m⁻² and spreads out to the lower intertidal subzone. The fauna is strongly dominated by Decapoda. The hermit crab *Clibanarius ransonii* makes up above 45% of the total biomass of macrobenthos and 90% of the total biomass of animals. The brachyuran crabs *Leptodius exaratus*, *Nanosesarma tweediei*, *N. minutum*, and *Ilyoplax pusilla*, the polychaete *Ceratonereis mirabilis*, rather large sea slug *Aplysia* sp., the bivalve mollusk *Codakia* sp., the sponge *Clathria* sp., and sipunculid worms are also found on peninsula.

The macrobenthic communities of the lower intertidal subzone of dead coral reefs are generally not clearly separated from the communities located in the middle intertidal subzone, but inhabitants of the lower subzone are much more diverse than dwellers of the middle subzone. For instance, on Hon Khoi Peninsula, immediately below *Palisada perforata*, a community dominated by the red alga *Tolypocladia glomerulata* and the sea cucumber *Holothuria (Halodeima) edulis* develops. This community also includes the red algae *Chondrophycus articulatus*, *Palisada parvipapillata*, and *Gelidiella acerosa*. The *T. glomerulata*+*H. (H.) edulis* community

are dominated by the gastropods *Clypeomorus petrosa chemnitziana* and *Drupella margariticola*, the bivalve mollusk *Arca ventricosa*, and the brachyuran crab *Leptodius exaratus*. The polychaetes *Perinereis cultrifera* and *Ceratonereis mirabilis*, the shrimp *Alpheus* sp., the brachyuran crabs *Nanosesarma tweediei*, *Metopograpsus messor*, and *Macromedaeus nudipes*, the gastropods *Tenguella musiva*, *Triphora* sp., and *Pythia* sp., sipunculid worms and some other groups of invertebrates may also be found in the lower intertidal subzone of Hon Khoi Peninsula. The total biomass of macrobenthos in the community may exceed 1 kgWW m^{-2} .

On Rua Islet (Nha Trang Bay), the *Sargassum* community dominated by *S. mcclurei*, *S. miyabei*, and *S. polycystum* may be found locally. Other numerous species include the gastropod *Turbo bruneus*, the bivalve mollusks *Leiosolenus malaccanus*, *Botula cinnamomea*, and *Rocellaria* sp., decapods, and holothurians. The total biomass of macrobenthos in the *Sargassum* community is rather high (above 4850 gWW m^{-2}).

On Bai Tien Beach, there is a community of *Sargassum* and red algae. Among the dense underbrush of *Sargassum* sp., *Laurencia tenera*, *Palisada perforata*, and *P. parvipapillata* develop. Sometimes the community comprises other red algae (*Gelidiella acerosa*, *Hypnea valentiae*, *Centroceras clavulatum*, *Anotrichium tenue*, *Leveillea jungermannioides*, *Boodlea struveoides*, and others). The gastropods *Conus coronatus* and *Erronea erronea* prevail among animals. The total biomass of macrobenthos is above 1280 gWW m^{-2} . Another community found on Bai Tien Beach is a belt-forming algal mosaic community dominated by the brown alga *Padina australis*, the green alga *Halimeda tuna*, and Rhodophyta. Typical for the lower intertidal subzone red algae include *Palisada parvipapillata*, *Laurencia tenera*, *L. microcladia*, *L. jungermannioides*, *Ceramium cingulatum*, *Hypnea pannosa*, *Gelidium crinale*, *Jania adhaerens*, and *Mastophora pacifica*. Other algae are represented by the brown alga *Dictyota dichotoma* and the green algae *Boergesenia forbesii* and *Phyllodictyon anastomosans*. Prevailing animals are barnacles and bivalve mollusks. The total biomass of macrobenthos may reach 1200 gWW m^{-2} in this algal community.

Live corals may be found in the lower part of the lower intertidal subzone in some areas. For instance, colonies of the hydrocoral *Millepora platyphylla*, the reef-building scleractinian corals (*Acropora digitifera*, *Porites lobata*, species of *Pocillopora*, *Favia*, *Psammocora*, and *Echinopora*), as well as corals that do not form reefs (*Dendrophyllia*) occur in Bau Than Bay.

Polychaetes, sipunculid worms, hermit crabs, and the bivalve mollusk *Atactodea striata* inhabit sandy areas of the middle and lower intertidal subzones. These areas are also characterized by quite numerous brachyuran crabs (up to 240 ind. m^{-2} and above 325 gWW m^{-2}).

High macrophyte diversity is observed in the communities of dead coral reefs in Bau Than Bay, on Bai Tien Beach, Rua Islet, Thi Island, and on Hon Khoi Peninsula, while very few algae are recorded on Lon Island, Me, Cum Meo, and Bip islets, in Ke, Nai, Ben Goi, and Ro bays. The fauna of these communities creates a patchwork of diverse groups of intertidal inhabitants in all study areas from Cape Dinh to Ro Bay. The species composition of animals depends on the topography of the coral plateau, the degree of wave action, and the degree of coral reef coverage by silted or pure sand. Animals recorded in the lower intertidal subzone, apart from those listed above, include sponges (*Cinachyrella australiensis*, *Haliclona* (Gellius) *ridleyi*, *H. (G.) cymaeformis*, *H. (G.) amboinensis*, *Haliclona* sp., and *Biemna fortis*), polychaetes (*Iphione muricata*, *Scoloplos* (*Leodamas*) *uniramus*, *Bhawania goodei*, *Palola siciliensis*, *Spirobranchus giganteus*, *Pista cristata*, *Leocrates claparedii*, *Lysidice collaris*, *Loimia medusa*, *Neanthes pachychaeta*, *Syllis* sp., and *Dodecaceria fistulicola*), decapods (*Thalamita danae*, *Th. prymna*, *Petrolisthes asiaticus*, *Actaeodes tomentosus*, *Calcinus laevimanus*, *Clibanarius lineatus*, *C. arethusa*, *C. merguiensis*, *Coenobita rugosus*, *Dardanus megistos*, and *Alpheus lobidens*), gastropods (*Scutus unguis*, *Trochus maculatus*, *Mauritia arabica*, *Canarium urceus*, *Polinices mammilla*, *Mammilla melanostoma*, *Clypeomorus pellucida*, *Polia undosa*, *Mitrella scripta*, *Nassarius graphiterus*, *Mitra ambigua*, *Nerita* sp., *Chicoreus brunneus*, *Tectus pyramis*, *Thalessa aculeata*, *Drupella rugosa*, and *Conus consors*), bivalves (*Gafrarium dispar*, *G. pectinatum*, *Modiolus auriculatus*, *Brachidontes mutabilis*, *Tellina clathrata*, *Dosinia exasperata*, *Spondylus sinensis*, *Isognomon legumen*, and *Pinctada nigra*), and echinoderms (*Linckia laevigata*, *Archaster typicus*, *Echinaster luzonicus*, *Ophiocoma* (*Breviturma*) *dentata*, *Ophiarthrum elegans*, *Heterocentrotus mamillatus*, *Holothuria* sp., *Holothuria* (*Halodeima*) *atra*, *H. (Mertensiothuria)* *leucospilota*, and *Actinopyga echinites*).

Intertidal zone of loose substrata

Marine silty-sandy and sandy beaches

Marine silty-sandy and sandy beaches are usually composed of silted mixed-grained sand with admixture of shells, gravel, pebbles, and dead coral fragments. Such coasts are rather widely represented on the shores of bays and islands in southern (Bau Than and Trau Nam bays, Tre, Thi, Lon, and Ong islands, Trong (Binh Cang Bay), Me and Ke islets (Ben Goi Bay), and Cape Co Co) and northern (Co To Island, Be and Tran Ca banks) Vietnam (Table 1). Sometimes mangrove thickets develop in the upper part of the intertidal zone on heavily silted beaches with shells. The species composition of macrobenthos is generally more abundant and diverse on heavily silted beaches with lots of shells than on slightly silted or sandy gravelly beaches.

In southern Vietnam, slightly silted beaches of the upper intertidal subzone are occasionally inhabited by crabs or the polychaetes *Perinereis nuntia* and others, with the total animal biomass within 20 gWW m⁻². Heavily silted beaches are characterized by an abundant fauna with a predominance of gastropods (*Nerita polita*, *N. chamaeleon*, *N. albicilla*, *Planaxis sulcatus*, *Echinolittorina millegrana*, *Clypeomorus batillariaeformis*, *C. pellucida*, *Cerithium traillii*, *Drupella margariticola*, *Semiricinula muricina*, *Reishia luteostoma*, *Cellana toreuma*) and bivalve mollusks (*Barbatia foliata*, *B. cometa*, *Pinctada margaritifera*, *Saccostrea scyphophilla*, *Septifer bilocularis*, *Loxoglypta transculpta*, *Gari elongata*, *Ruditapes philippinarum*). The total biomass of mollusks can reach 920 gWW m⁻². In mangrove thickets, mollusks prevail, too, and Cerithiidae are mainly dominant on the sand (Table 17). These habitats

Table 17

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the upper intertidal subzone of marine silted-sandy beaches with admixture of shell, in the Cerithiidae community (southern Vietnam)

Taxa	Taxonomic group	B	N
ANIMALS			
Gastropoda	Ga	2680.4	2740
Including			
<i>Cerithium traillii</i>	Ga	169.4	140
<i>Nerita albicilla</i>	Ga	26.6	18
<i>Clypeomorus pellucida</i>	Ga	16.6	15
<i>Drupella margariticola</i>	Ga	10.1	16
<i>Planaxis sulcatus</i>	Ga	6.1	93
<i>Nerita chamaeleon</i>	Ga	3.4	3
<i>Nerita polita</i>	Ga	3.0	8
<i>Cerithium</i> sp.	Ga	2.6	3
<i>Littoraria scabra</i>	Ga	0.2	1
<i>Cellana toreuma</i>	Ga	0.1	1
Bivalvia	Bi	87.5	73
Including			
<i>Loxoglypta transculpta</i>	Bi	65.0	57
<i>Asaphis violascens</i>	Bi	22.0	16
<i>Scoloplos</i> sp.	Po	2.2	31
Decapoda	De	1.9	20
<i>Chthamalus malayensis</i>	Ci	0.3	–
Amphipoda	Am	0.1	4
Total biomass		3097.4	

also host a wide variety of bivalve mollusks (*Pinctada margaritifera*, *Gafrarium pectinatum*, *Brachidontes setiger*, *Parapholas quadrizonata*, *Botula cinnamomea*, *Leiosolenus malaccanus*, *Malleus legumen*, *Dosinia troscheli*, and others) and crustaceans.

The middle intertidal subzone of silted-sandy beaches is dominated by bivalves (*Modiolus auriculatus*, *Brachidontes striatulus*, *B. setiger*, *B. mutabilis*, *Isognomon nucleus*, *I. ephippium*, *I. perna*, *I. isognomum*, *Ruditapes philippinarum*, *Gafrarium dispar*, *G. pectinatum*, *G. divaricatum*, *Asaphis violascens*, *Pinna muricata*, *Arca ventricosa*, *Striarca symmetrica*, *Venus cassinaeformis*, *Rocellaria* sp., *Chama pacifica*, *Pegophysema bialata*, *Coralliophaga* sp., *Corbula* sp., *Ostrea* sp., *Septifer excisus*, *S. bilocularis*, *Atactodea striata*, *Venerupis variegata*, and *Saccostrea scyphophilla*). Gastropods are second in terms of biomass (Table 18). In addition to quantitatively

Table 18

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the middle intertidal subzone of marine silted-sandy beaches with admixture of shell (southern Vietnam)

Taxa	Taxonomic group	B	N
ANIMALS			
Bivalvia	Bi	185.9	98
Gastropoda	Ga	55.0	87
Including			
<i>Clypeomorus pellucida</i>	Ga	8.9	8
<i>Drupella margariticola</i>	Ga	8.1	11
<i>Drupa</i> sp.	Ga	5.1	3
<i>Monetaria annulus</i>	Ga	4.5	2
<i>Nerita albicilla</i>	Ga	4.4	2
<i>Rhinoclavis aspera</i>	Ga	3.3	22
<i>Nerita polita</i>	Ga	2.2	1
<i>Nerita chamaeleon</i>	Ga	2.2	1
<i>Semiricinula muricina</i>	Ga	2.0	1
<i>Erronea erronea</i>	Ga	1.7	1
<i>Cerithium</i> sp.	Ga	1.3	3
<i>Aplysia</i> sp.	Ga	1.0	1
<i>Triphora</i> sp.	Ga	0.1	1
<i>Voluta</i> sp.	Ga	0.1	1
<i>Murex</i> sp.	Ga	0.1	1
<i>Natica</i> sp.	Ga	0.1	1

Table 18 (Continued)

Taxa	Taxonomic group	B	N
<i>Ophiocoma scolopendrina</i>	Oph	14.4	5
<i>Haliclona</i> (Gellius) <i>cymaeformis</i>	Sp	13.5	
Holothuroidea	Ho	7.0	9
Actiniaria	Ac	5.1	15
Polychaeta	Po	4.2	102
Including			
<i>Iphione muricata</i>	Po	0.1	1
<i>Lysidice unicornis</i>	Po	0.1	1
<i>Perinereis cultrifera</i>	Po	0.1	1
<i>Cirratulus</i> sp.	Po	0.1	3
<i>Linopherus paucibranchiata</i>	Po	0.1	3
<i>Scoloplos</i> sp.	Po	0.1	3
<i>Epixanthus frontalis</i>	De	1.2	4
<i>Penaeus latisulcatus</i>	De	0.9	1
<i>Clibanarius eurysternus</i>	De	0.7	11
<i>Heteropanope glabra</i>	De	0.3	5
<i>Alpheus strenuus strenuus</i>	De	0.2	1
<i>Leptodius exaratus</i>	De	0.1	1
<i>Nanosesarma minutum</i>	De	0.1	4
<i>Thalamita prymna</i>	De	0.1	1
<i>Dardanus deformis</i>	De	0.1	1
Total biomass		302.9	

recorded species, *Littoraria scabra*, *Planaxis sulcatus*, and *Terebralia sulcata* may be found here. Mollusks make up above 90% of the total biomass of macrobenthos. Besides, the middle subzone is inhabited by brittle stars, sponges, sipunculid worms, shrimps, hermit crabs (*Clibanarius longitarsus*, *Coenobita rugosus*, and others), brachyuran crabs (*Thalamita crenata*, *Ocypode cordimanus*, *O. convexa*, *Ozius lobatus*, *Ashtoret lunaris*, *Mictyris longicarpus*, and others), sea cucumbers (*Holothuria* (*Thymiosycia*) *impatiens*, *Synaptula* sp., and *Anapta* sp.), polychaetes, the inarticulate brachiopod *Lingula* sp., sea anemones, sea urchins, amphipods, and isopods, and others groups of invertebrates. Algal species include the green alga *Avrainvillea erecta* and the brown alga *Padina boryana*; the epiphytic green alga *Cladophoropsis membranacea* grows in the middle intertidal subzone.

A community dominated by the seagrass *Enhalus acoroides* with the total biomass about 4 kgWW m⁻² sometimes occurs in the lower intertidal subzone. The flora of the community comprises the seagrass *Halodule pinifolia* and the red alga *Hydrolithon farinosum*. Prevailing animals include gastropods (*Drupella margariticola*, *Monetaria annulus*, *Erronea erronea*, and *Vexillum rugosum*) and bivalve mollusks (*Barbatia foliata*, *Anadara antiquata*, *Modiolus auriculatus*, and *Isognomon perna*). Sea urchins of the family Loveniidae and common and hermit crabs also frequently occur in the *E. acoroides* community.

Some sandy beaches are dominated by the gastropod *Rhinoclavis aspera*, others, by the bivalve mollusk *Atactodea striata* and many various crab species. However, the total animal biomass is commonly less than 50 gWW m⁻² in these communities. On the other hand, the animal biomass exceeding 2150 gWW m⁻² is recorded in the community dominated by the colonial soft coral *Zoantharia* (Table 19).

The population of silty-sandy beaches with a strong admixture of shells includes diverse fauna in the lower intertidal subzone: sponges (*Halichondria* (*Halichondria*) *cartilaginea*, *Haliclona* sp., and *Callyspongia* (*Callyspongia*) *monilata*), polychaetes (*Eurythoe complanata*, *Thelepus plagiostoma*, and *Scoloplos* (*Leodamas*) *uniramus*), the mantis shrimp *Gonodactylus chiragra*, the shrimp *Alpheus bisincisus*, hermit crabs (*Clibanarius virescens*, *C. lineatus*, and *C. cruentatus*), brachyuran crabs (*Thalamita danae*, *Th. crenata*, *Pilumnus vespertilio*, *Epixanthus frontalis*, *Ozium rugulosus*, *Mictyris longicarpus*, *Metopograpsus messor*, *M. oceanicus*, *Macrophthalmus* (*Macrophthalmus*)

Table 19

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the upper part of the lower intertidal subzone of marine silted-sandy beaches, in the community of *Zoantharia* (southern Vietnam)

Taxa	Taxonomic group	B	N
ANIMALS			
<i>Zoantharia</i>	Zo	1632.8	1380
<i>Modiolus auriculatus</i>	Bi	391.1	100
<i>Nerita chamaeleon</i>	Ga	38.1	20
<i>Anadara antiquata</i>	Bi	28.9	20
<i>Holothuria</i> (<i>Thymiosycia</i>) <i>impatiens</i>	Ho	27.1	40
<i>Drupella margariticola</i>	Ga	25.6	20
<i>Biemna fortis</i>	Sp	6.1	
<i>Thelepus plagiostoma</i>	Po	1.9	20
Total biomass		2151.6	

brevis, *Leptodius exaratus*, and *Ocypode ceratophthalmus*), the chiton *Tonicia* sp., gastropods (*Haliotis ovina*, *Trochus maculatus*, *Angaria delphinus*, *Volegalea cochlidium*, *Erronea erronea*, *Nerita polita*, *N. chamaeleon*, *N. albicilla*, *N. undata*, *Planaxis sulcatus*, *Canarium urceus*, *Cypraea* sp., *Mitrella scripta*, *Cerithium traillii*, *Clypeomorus pellucida*, *Strobiliger inflata*, *Monoplex pilearis*, *Nassarius pullus*, *Drupella margariticola*, *Muricodrupa fiscella*, *Reishia luteostoma*, *Aplysia* sp., and *Siphonaria sirius*), bivalve mollusks (*Gafrarium pectinatum*, *G. dispar*, *Striarca symmetrica*, *Arca ventricosa*, *Barbatia cometa*, *B. foliata*, *Spondylus* sp., *Chama macerophylla*, *Modiolus philippinarum*, *M. auriculatus*, *Atactodea striata*, *Isognomon isognomonum*, *I. nucleus*, *I. australica*, *Septifer bilocularis*, *Electroma virens*, *Atrina strangei*, *Saccostrea scyphophilla*, *Dendostrea sandvichensis*, *D. folium*, *Limaria perfragilis*, *Pinctada margaritifera*, *P. radiata*, *P. nigra*, and *Gafrarium pectinatum*, the sea star *Archaster typicus*, brittle stars (*Ophiopsis superba*, *O. cincta cincta*, and *Ophiactis savignyi*), sea urchins (*Prionocidar baculosa* and *Echinometra mathaei*), and the sea cucumber *Holothuria* (*Thymiosycia*) *impatiens*.

In the northern Vietnam (Co To Beach on Co To Island), the supratidal zone and the upper intertidal subzone of slightly silted sandy beaches are mainly inhabited by terrestrial and freshwater members of Pulmonata, Arachnoidea, Myriapoda, the mud lobster *Thalassina anomala*, a common dweller of the mangrove swamps, the brachyuran crabs belonging to the genus *Sesarma*, the hermit crabs of the genus *Coenobita*, and the isopod *Ligia* sp. The crab *Epixanthus frontalis* is sometimes found under seagrass wrack and rare boulders. The crabs *Ocypode ceratophthalmus*, *Scopimera bitympa*, *Perisesarma eumolpe*, and *Parasesarma plicatum* occasionally occur in the lower part of the upper intertidal subzone, as well as in southern Vietnam. *Dotilla wichmanni*, *Metopograpsus thukubar* and the gastropod *Cerithideopsilla cingulata* (up to 300 ind. m⁻²) are more widespread species.

In the middle intertidal subzone, the light-blue soldier crab *Mictyris longicarpus* lives on the sandy beach, and occasionally the mud shrimp *Callinassa* sp., the mangrove swimming crab *Thalamita crenata*, the polychaetes *Chaetopterus* sp. and *Ophelina* sp., the bivalve mollusks *Gomphina* sp., *Donax faba*, and *Anomalocardia* sp., and the gastropods *Neritina* sp. and *Cerithideopsilla cingulata* may be found there.

The lower intertidal subzone is characterized by dense accumulation of species, including subtidal species. The bivalves *Circe* sp., *Meretrix meretrix*, *Corbula ovalina*, *Arca* sp., and *Placamen isabellina*, the sea stars *Astropecten scoparius* and *Archaster typicus*, the sea urchins *Laganum* sp. and *Temnopleurus toreumaticus*, the sea cucumbers *Cucumaria frondosa japonica* and *Holothuria* (*Mertensiothuria*) *leucospilota*, the gastropods *Umbonium thomasi*, *Trochus* sp., *Nassarius bellulus*, *Strombus* sp., *Haliotis diversicolor*, and *H. ovina*, the brachyuran crabs *Portunus* (*Portunus*)

pelagicus, *Ashtoret lunaris*, *Macrophthalmus* (*Macrophthalmus*) *brevis*, and *Eurycarcinus orientalis*, the mantis shrimp *Cloridopsis scorpio*, small hermit crabs, scattered settlements of the polychaete *Diopatra neapolitana*, the sedentary polychaetes of the family Sabellidae, and small fishes *Siganus fuscescens*, *Arothron stellatus*, and *Pomadasys* sp. are recorded on the slightly silted sandy Co To Beach (Gurjanova, Chang Hiu Phuong, 1972).

In the Gulf of Tonkin, the silty-sandy Be and Tran Ca banks (Bai Tu Long Archipelago), disconnected from the shore and fully covered with water at equatorial tides, were also studied. The upper intertidal subzone is absent on the banks.

A continuous belt of seagrass *Cymodocea* sp. is spread along the middle and lower intertidal subzones. Prevailing species of macrobenthos on Be and Tran Ca banks are generally similar to those of Co To Beach, but apart from the animals mentioned for the beach, the *Cymodocea* sp. community also includes the following species: the brachyuran crabs *Uca* sp., *Macrophthalmus* (*Macrophthalmus*) *crassipes*, *M. dilatatus sulcatus*, *M. (Mareotis) tomentosus*, the shrimps of the family Alpheidae, the bivalves *Solen* sp., *Dosinia* sp., and *Macoma* sp., the sipunculid worm *Sipunculus* (*Sipunculus*) *nudus*, and the polychaetes *Chaetopterus variopedatus*.

Besides, the middle intertidal subzone and the upper part of the lower intertidal subzone are occupied by a community of the sedentary polychaetes of the family Sabellidae and the seagrass *Halophila beccarii*. Other members of the community include: rich crab fauna (*Macrophthalmus* (*Macrophthalmus*) *convexus*, *M. (Paramareotis) erato*, *M. (Mareotis) pacificus*, *M. (Mareotis) definitus*, *Metaplex longipes*, *M. sheni*, *Tmethypocoelis ceratophora*, *Ilyoplax orientalis*, *Metopograpsus quadridentatus*, *Pinnotheres* sp., *Polyonyx* sp., *Ebalia* sp., *Rhizopa gracilipes*, *Camptandrium sexdentatum*, *Charybdis* (*Charybdis*) *anisodon*, *Benthopanope eucratoides*, *Typhlocarcinus* sp., *Neoxenophthalmus obscurus*, *Perisesarma bidens*, *Eurycarcinus* sp., and others), gastropods (*Drupella rugosa*, *Indothais blanfordi*, *Turritella bacillum*, *Mitra* sp., *Nassarius pullus*, *Nassarius* sp., and others), bivalve mollusks (*Placuna placenta*, *Codakia* sp., *Laternula anatina*, *Cyclina sinensis*, *Gafrarium* sp., *Macra* sp., and others), polychaetes (*Lanice conchilega* and others), species of Ophiuroidea, the numerous juvenile horseshoe crabs *Tachypleus*, and other animals.

A community dominated by another seagrass species, *Halophila ovalis*, occurs in the lower part of the lower intertidal subzone. It contains the sponge *Tethya japonica*, sea pens, sea cucumbers, shrimps, the brachyuran crabs *Thalamita* spp., *Serfukiensis*, and others, the gastropod *Laevistrombus turturella*, the bivalve mollusk *Pinna* sp., the sea anemone *Halcampella maxima*, numerous sea star *Astropecten scoparius* and fishes *Pomadasys* sp. (Gurjanova, Chang Hiu Phuong, 1972).

Estuarine-lagoonal intertidal zone

The estuarine-lagoonal intertidal zones are located in sheltered places, such as bays and inlets, with weak wave action and low salinity of water. Bottom deposits of estuarine beaches mainly consist of silted sand or clayed silt with admixture of shells, gravel, stony and dead coral debris. In the Gulf of Tonkin, sedimentary deposits make up to 30 cm in thickness on the mudflats. Mangroves as a rule develop in the upper part of the intertidal zone. Estuarine beaches were studied in some areas of southern (Tre Island (Dam Chinh Bay), innermost parts of Binh Cang and Ben Goi bays, and at Vung Tau) and northern (the Red River Delta, Danh Do La and Dao Trao islands) Vietnam. A coastal lagoon is described in an unnamed bay of Hon Gom Peninsula (Cua Be Strait) (Table 1).

A typical coastal lagoon 1 m deep on Hon Gom Peninsula is located 15 m off the intertidal zone, cut off from the open sea by a sandbar and connected to the sea by a narrow channel. The sea water flows out of the lagoon during low tide, while from the opposite side a small stream flows into the lagoon. The lagoon is surrounded on one side by rocky blocks and on the other side by sand (Fig. 13). The bottom of the lagoon is covered by silted sand. Mangrove trees grow along a sandbank. The rocky blocks above the water's edge are only covered with littorinids and very rare oysters (mainly dead). Below the water's edge, *Diadema* sea urchins may sometimes be found in cracks and crevices. Burrows of crabs are seen on the sand in the upper intertidal subzone, but the lagoon bottom appears absolutely lifeless. The blennioid fishes *Salarias* swim in the water.

In southern Vietnam, the upper intertidal subzone of estuarine beaches is mainly inhabited by gastropods. A community dominated by *Cerithium coralium* occurs in the innermost parts of Binh Cang Bay (Nha Phu Bay), at Tan Thuy (Table 20). In addition to quantitatively recorded species, there are also numerous brachyuran crabs *Uca* spp., the gastropod species *Neritina* sp., *Cerithium* sp., and *Littoraria melanostoma*. The gastropod species *Littoraria scabra* occurs on trunks of the mangroves *Sonneratia*, *Avicennia* and *Rhizophora* (Tran-ngoc Loi, 1967). In Trau Nam Bay (the innermost parts of Ben Goi Bay), a community dominated by *Clithon oualaniense*+*Cerithideopsilla cingulata* develops. The population is much more diverse and quantitatively abundant in Dam Chinh Bay than in Binh Cang and Trau Nam bays.

The middle intertidal subzone is inhabited poorer than the upper subzone. In the innermost part of Dam Chinh Bay, the total biomass of macrobenthos is 22.5 gWW m⁻². Prevailing species include polychaetes, the inarticulate brachiopod *Lingula* sp., sipunculid worms, and the bivalve mollusk *Tellina clathrata*. Only the fiddler crab *Uca* (*Gelasimus*) *vocans* and small sipunculid worms may be



Fig. 13. A lagoon on the south-western coast of Hon Gom Peninsula (Cua Be Strait, Van Phong Bay). Photograph by Alexey V. Chernyshev.

found in Trau Nam Bay. The macrobenthos of Nha Phu Bay is relatively diverse. For example, it includes the rare seagrass *Halodule uninervis* (810 gWW m⁻²). Several species of mollusks (the bivalves *T. clathrata*, *Gonimyrtea* sp., and *Ctena delicatula*, and the gastropod species *Clithon oualaniense*, *Indothais javanica*, *Cerithium coralium*, and *Assimineia* sp.) dominate, with the total biomass above 70 gWW m⁻² and density up to 1000 ind. m⁻². Polychaetes, sipunculid worms, the hermit crab *Clibanarius eurysternus*, common crabs, and occasionally the bivalves *Pitar sulfureus* and *Anadara gubernaculum*, and the gastropods *Drupella rugosa* and *Ergaea walshi* may also be found in the innermost part of Binh Cang Bay.

At Tan Thuy, a belt dominated by the oyster *Striostrea margaritacea* and the tube-building polychaete *Pomatoceros caeruleus* develops on mangrove trunks. A community of the small-sized (up to 3 mm) barnacles *Chinochthamalus scutelliformis* is observed on mangrove trunks with the projective cover up to 100%. On some mangroves, where settlements of oysters are sparse, a community dominated by the red algae *Bostrychia tenella* and *Catenella nipae* develops (Tran-ngoc Loi, 1967).

Table 20

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos
in the upper intertidal subzone of estuarine beaches

Taxa	Taxonomic group	Dam Chinh Bay, Tre Islet		Nha Phu Bay, Binh Cang Bay		Trau Nam Bay, Ben Goi Bay	
		B	N	B	N	B	N
ANIMALS							
<i>Nerita albicilla</i>	Ga	278.6	320	–	–	–	–
<i>Isognomon isognomum</i>	Bi	185.0	100	–	–	–	–
<i>Drupa</i> sp.	Ga	153.8	80	–	–	–	–
<i>Clithon oualaniense</i>	Ga	–	–	3.9	120	152.6	2992
<i>Nerita polita</i>	Ga	89.6	160	–	–	–	–
<i>Natica</i> sp.	Ga	83.0	100	–	–	–	–
<i>Cerithideopsilla cingulata</i>	Ga	–	–	–	–	80.8	100
<i>Cerithium coralium</i>	Ga	–	–	79.0	565	–	–
<i>Assimineae</i> sp.	Ga	75.0	1220	0.4	20	–	–
<i>Echinolittorina millegrana</i>	Ga	50.8	640	–	–	–	–
<i>Patelloida saccharina</i>	Ga	34.2	40	–	–	–	–
Paguridae	De	5.8	40	–	–	–	–
<i>Mictyris longicarpus</i>	De	–	–	–	–	5.8	7
<i>Tellina clathrata</i>	Bi	–	–	5.4	10	–	–
<i>Aplysia</i> sp.	Ga	–	–	–	–	3.1	2
<i>Perinereis nuntia</i>	Po	–	–	2.2	95	0.2	3
<i>Macrophthalmus</i> (<i>Macrophthalmus</i>) <i>brevis</i>	De	–	–	1.9	10	–	–
Total biomass		875.8		92.8		242.5	

Communities dominated by bivalve mollusks (*Anadara antiquata* in Dam Chinh Bay and *Gafrarium pectinatum* in Trau Nam Bay) occupy the lower intertidal subzone (Table 21). In Nha Phu Bay, both epifauna and infauna are diverse. Frequently occurring animals include the gastropod species *Drupella rugosa* with its egg masses, the hermit crab *Clibanarius* sp., the brachyuran crabs *Chlorodiella nigra* and *Benthopanope eucratoides*, and *Balanus* barnacles (attached to molluskan shells and dead branches of mangroves). Among other species recorded in the lower intertidal subzone, there are polychaetes, amphipods, and oligochaetes, the gastropods *Nerita chamaeleon*, *Clithon oualaniense*, *Mitra* sp., *Indothais javanica*, and *Drupella margariticola*, the bivalve mollusks *Anadara gubernaculum*, *A. antiquata*,

Table 21

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos
in the lower intertidal subzone of estuarine beaches

Taxa	Taxonomic group	Dam Chinh Bay, Tre Islet		Trau Nam Bay, Ben Goi Bay	
		B	N	B	N
ANIMALS					
<i>Anadara antiquata</i>	Bi	85.4	7	–	–
<i>Gafrarium pectinatum</i>	Bi	–	–	43.4	23
<i>Rhinoclavis aspera</i>	Ga	29.7	260	–	–
<i>Archaster typicus</i>	As	27.4	13	–	–
<i>Polinices mammilla</i>	Ga	–	–	13.2	60
<i>Dosinia troscheli</i>	Bi	10.1	87	0.3	4
Polychaeta	Po	–	–	9.4	–
<i>Nassarius pullus</i>	Ga	8.9	7	–	–
Decapoda	De	–	–	7.9	10
<i>Lingula</i> sp.	Br	–	–	5.0	15
<i>Anomalodiscus squamosus</i>	Bi	3.4	7	–	–
<i>Clithon oualaniense</i>	Ga	2.8	20	–	–
<i>Venus</i> sp.	Bi	0.7	13	–	–
<i>Dodecaceria fistulicola</i>	Po	0.4	7	–	–
<i>Loxoglypta transculpta</i>	Bi	0.3	7	0.3	4
Total biomass		169.1		79.5	

Anomalodiscus squamosus, *Arca* sp., *Placuna placenta*, *Ostrea* sp., and shallow-water fishes. Patches of the green alga *Ulva flexuosa* and the seagrass *Thalassina anomala* are found on silted sand in the lower intertidal subzone of Tan Thuy (Tran-ngoc Loi, 1967). At Vung Tau, mangrove trunks are covered by rare individuals of the barnacle *Chthamalus* cf. *stellatus* and numerous scabra periwinkles *Littoraria scabra* (Fischer, 1952).

In northern Vietnam, the intertidal zone with mangrove thickets is found in many areas along the shore of the Red River Delta (estuaries of the Day, Van Uc, Cam rivers, the main channel of the Red River Ba Lat, An Kim Hai Canal), and on Danh Do La and Dao Trao islands (Table 1).

Marine, freshwater, and air-breathing aquatic invertebrates occur within mangrove forests (the mangrove trees *Sonneratia caseolaris*, *Acanthus ilicifolius*, *Aegiceras corniculatum*, *Ceriops* sp., *Avicennia marina*, and others) of the Red River Delta.

The supratidal zone and the upper intertidal subzone are inhabited by the animals that can rise above the average level of tropical tides (the brachyuran crabs (*Uca* (*Austruca*) *lactea*, *U. (Tubuca)* *forcipata*, *U. (T.) arcuata*, *Uca* sp., *Perisesarma eumolpe*, *P. bidens*, *Parasesarma moluccense*, *Sesarma dehaani*, *Neosarmatium smithi*, *Tmethypocoelis ceratophora*, *Metaplax elegans*, *M. longipes*, *Helice tridens*, *Macrophthalmus* (*Macrophthalmus*) *brevis*, and *Paracleistostoma depressum*), the gastropods (*Littorinopsis* sp., *Littoraria melanostoma*, *Neritina violacea*, *Terebralia sulcata*, and *Cerithideopsilla cingulata*), including the pulmonate gastropods *Ellobium* sp. and *Onchidium* sp. The crabs of the genera *Metaplax*, *Uca*, *Sesarma*, and *Macrophthalmus*, as well as *Ilyoplax orientalis*, *Camptandrium sexdentatum*, *Deiratonotus cristatum*, and others may migrate all the way down the intertidal zone to the sublittoral fringe. The sipunculid worm *Phascolosoma* sp., the brachyuran crabs *Sarmatium crassum*, *Scylla serrata*, and *Clistocoeloma merguense*, the gastropod *Assimineia* sp., turbellarian flatworms, and the mudskipper *Boleophthalmus* sp. are found from the lower part of the upper intertidal subzone to the middle intertidal subzone.

The brachyuran crabs *Ilyoplax pingi* and *Episesarma mederi*, the gastropods *Nerita* sp. and *Nassarius* sp., the bivalve mollusk *Cyclina sinensis*, and echiurid worms occur on the boundary between the upper and middle intertidal subzones and in the upper part of the middle intertidal subzone. The seagrass *Halophila beccarii*, bivalve mollusks (*Laternula anatina*, *Codakia* sp., *Placuna placenta*, and others), the inarticulate brachiopod *Lingula anatina* and brachyuran crabs (*Uca* (*Tubuca*) *dussumieri* and *Metopograpsus quadridentatus*) are frequently recorded in the middle intertidal subzone.

Various crabs (*Metopograpsus latifrons*, *Orithyia sinica*, *Neoxenophthalmus obscurus*, *Parasesarma batavianum*, and *Metaplax sheni*) and the common button top shell *Umbonium* sp. are found both in the middle and lower intertidal subzones. Most part of the lower intertidal subzone to the subtidal zone is inhabited by the brachyuran crabs *Philyra olivacea*, *Rhizopa gracilipes*, *Portunus* (*Portunus*) *pelagicus*, *Varuna litterata*, and *Serfukiensis*, hermit crabs, and the horseshoe crab *Tachypileus tridentatus*. These subzones also host the gastropod *Natica* sp. and the mantis shrimp *Cloridopsis scorpio* (Gurjanova, Chang Hiu Phuong, 1972).

In the Red River Delta, extensive estuarine beaches Dai Hop and Bang La (Table 1) are devoid of mangrove vegetation. Macrobenthic population is poorer on these beaches than in the areas of mangrove forests, though the species composition of the lower intertidal subzone is similar. The upper and middle intertidal subzones are not protected from sunlight by higher plants, but in the supratidal zone the salt tolerant vine *Ipomoea pes-caprae* (bayhops) and the coastal form of the screw pine *Pandanus tectorius* may be found. Sometimes the mud-crabs *Helice tridens* and *Helice* sp., the pebble-crab *Philyra* sp., and the sand-bubbler crab *Dotilla wichmanni* form dense aggregations extending across sandy beaches.

In the upper intertidal subzone, the brachyuran crabs *Scopimera bitympa*, *S. globosa*, and *Parasesarma pictum* are common on sandy shores, and salt marsh grasses are occupied by the crabs *Uca (Tubuca) arcuata*, *U. (T.) forcipata*, *U. (Austruca) lactea*, *Uca* sp., *Macrophthalmus (Paramareotis) erato*, and *Eurycarcinus orientalis* may also be found here. The horned ghost crab *Ocypode ceratophthalmus* has been observed to burrow in areas where the sand is soft enough. The bivalve mollusk *Glaucanome cerea* (collected by native people) occurs in red clay deposits.

The middle intertidal subzone is inhabited by extensive aggregations of the infaunal bivalve mollusk *Corbula* sp., the crabs *Macrophthalmus dilatatus sulcatus* and *Mictyris longicarpus*, and the saltwater clam *Meretrix meretrix*. The sedentary polychaete *Diopatra neapolitana* is recorded in the middle and lower intertidal subzones.

In the lower intertidal subzone, the crabs *Philyra olivacea*, *Camptandrium sexdentatum*, *Neoxenophthalmus obscurus*, *Macrophthalmus (Mareotis) tomentosus*, *Orithyia sinica*, and *Metaplex sheni*, the hermit crabs of the family Paguridae, echiurid worms, *Natica* gastropods, mantis shrimps of Squillidae, and young horseshoe crabs live on the surface of the thick layer of silt. Numerous crustaceans belonging to the groups Tanaidacea, Penaeidae, and Mysidacea, as well as the crab *Dorippoides facchino* inhabit fine deposits of silt. Commercial species of crabs, *Portunus (Portunus) pelagicus* and *P. (P.) trituberculatus*, occur at the water's edge, as they cannot survive out of water for long periods. Sea pens are found in the subtidal fringe (Gurjanova, Chang Hiu Phuong, 1972).

On Danh Do La and Dao Trao islands, the estuarine intertidal zone is up to 200 m wide and located in inlets (Table 1). The macrobenthos of the intertidal zone is impoverished, the vertical distribution of the communities exhibits insignificant stratification, and a patchy pattern of macrobenthic distribution is typical for these locations. Soft bottom substrata provide habitats for various infaunal species of Polychaeta and Sipuncula. Members of epifauna (oysters and barnacles) inhabit hard substrata and trunks, branches, and roots of mangrove trees. Macrophytes are almost absent, as the sea water has near zero transparency.

Thickets of the mangrove plant *Aegiceras* sp. and solitary shrubs of mangroves covered by sea water during high tides can be observed in the upper intertidal subzone (Fig. 14). On Dao Trao Island, a community dominated by *Dendostrea folium* forms a belt on mangrove trunks with the total biomass of macrobenthos above 2700 gWW m⁻² (Fig. 15; Table 22). The bivalve mollusks *Gafrarium pectinatum*, *Dicathifer manni*, and *Kellia* sp. and the gastropod *Nerita insculpta* settle on trunks, branches, and roots of mangroves. Stony and coral debris are inhabited by the oyster *Saccostrea echinata*, and the barnacles *Amphibalanus reticulatus* and *Chthamalus malayensis*. In addition to quantitatively recorded species, plenty of gastropods (*Nerita signata*, *Lunella granulata*, and *Planaxis sulcatus*) and their egg

masses, the bivalve mollusk *Placuna placenta*, the isopod *Ligia* sp., and the brachyuran crab *Metopograpsus* sp. may also be found in the upper intertidal subzone on Danh Do La Island. The macrobenthic population of Danh Do La Island is poorer than that on Dao Trao Island, but the species compositions of the estuarine intertidal zones in general are similar for both islands. A community of the bivalve mollusks *Isognomon ephippium*+*Brachidontes mutabilis* is found in stony debris. Other bivalve species (*P. placenta*, *Kellia* sp., *Dicyathifer mannii*, and others), gastropods (*Nerita insculpta* and *N. balteata*), brachyuran crabs (*Heteropanope glabra* and a few species of *Sesarma*), and some other invertebrates frequently occur in the upper intertidal subzone of Danh Do La Island (Fig. 16).

In the middle intertidal subzone of Dao Trao Island, plantlets of the red algae *Gelidium*, *Peyssonnelia*, and the green alga *Cladophora* may be observed. A belt-forming community dominated by the oyster *Saccostrea echinata* develops on stony and coral debris, and *S. echinata* makes up 80% of the animal bio-



Fig. 14. The mangrove shrubs in the upper intertidal subzone of Danh Do La Island (Bai Tu Long Archipelago, Gulf of Tonkin).

mass (Table 22). In addition to quantitatively recorded species, the sea anemone *Diadumene lineata*, the barnacle *Tetraclita squamosa*, the gastropods *Planaxis sulcatus*, *Drupella margariticola*, *Nerita signata*, and pulmonate gastropods are recorded in the *S. echinata* community. The crabs *Thalamita crenata* and *Metopograpsus* sp. are hiding into cracks and crevices of stony and coral debris and under them. On Danh Do La Island, algae are absent, and a community of the bivalve mollusks *Gafrarium pectinatum*+*Anomalodiscus squamosus* forms a mosaic of patches on stony debris. The dominant species make up about 80% of the total biomass of macrobenthos. Gastropods (*Clypeomorus batillariaeformis*, *Nassarius pul-lus*, *N. olivaceus*, *Volegalea cochli-dium*, *Neohaustator fortilirata*,

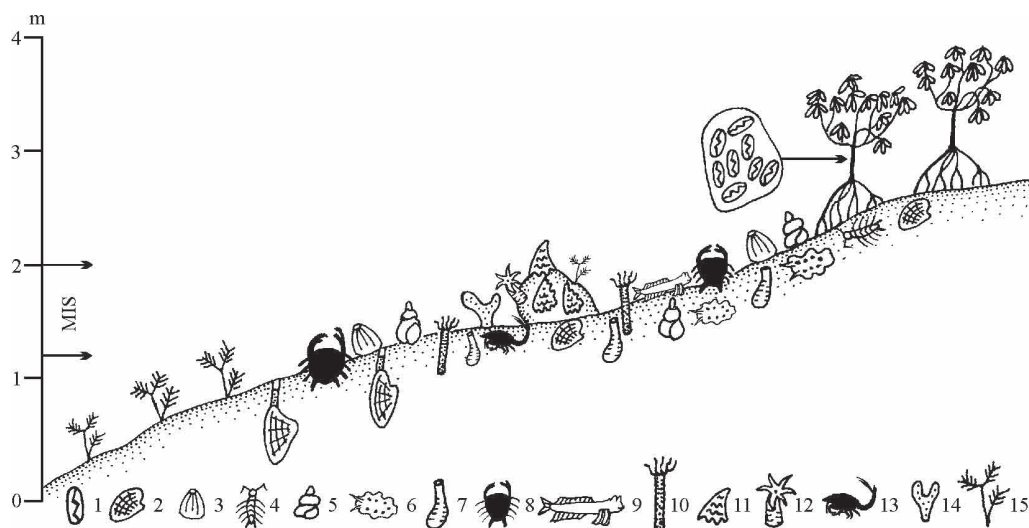


Fig. 15. Scheme of distribution of macrobenthos in the estuarine intertidal zone (Dao Trao Island, Bai Tu Long Archipelago, Gulf of Tonkin). 1 – *Dendostrea folium*, 2 – Bivalvia, 3 – Cirripedia, 4 – Isopoda, 5 – Gastropoda, 6 – Onchidiidae, 7 – Sipuncula, 8 – Decapoda, 9 – Blenniidae, 10 – Polychaeta, 11 – *Saccostrea echinata*, 12 – Actiniaria, 13 – Cumacea, 14 – Spongia, 15 – algae. Vertical scale – range over depths 0. MIS – the middle intertidal subzone.

Table 22

Biomass (B, gWW m⁻²) and density (N, ind. m⁻²) of macrobenthos in the intertidal zone of estuarine beaches (Gulf of Tonkin)

Taxa	Taxonomic group	Dao Trao Island				Danh Do La Island			
		Upper intertidal subzone		Middle intertidal subzone		Upper intertidal subzone		Middle intertidal subzone	
		B	N	B	N	B	N	B	N
PLANTS									
<i>Gelidium</i> sp.	Rh	–		50.0		–		–	
<i>Cladophora</i> sp.	Ch	–		6.4		–		–	
Total biomass of plants				56.4					
ANIMALS									
<i>Dendostrea folium</i>	Bi	2733.0	400	–	–	–	–	–	–
<i>Saccostrea echinata</i>	Bi	+	+	706.2	80	–	–	–	–
<i>Gafrarium pectinatum</i>	Bi	+	+	44.8	4	+	+	550.0	40
<i>Anomalodiscus squamosus</i>	Bi	+	+	17.3	28	+	+	420.0	80
<i>Isognomon ephippium</i>	Bi	–	–	–	–	250.0	40	–	–

Table 22 (Continued)

Taxa	Taxonomic group	Dao Trao Island				Danh Do La Island			
		Upper intertidal subzone		Middle intertidal subzone		Upper intertidal subzone		Middle intertidal subzone	
		B	N	B	N	B	N	B	N
<i>Brachidontes mutabilis</i>	Bi	–	–	6.0	8	180.0	20	68.0	120
<i>Neotrapezium sublaevigatum</i>	Bi	–	–	+	+	–	–	82.0	60
<i>Barbatia foliata</i>	Bi	–	–	–	–	–	–	80.0	20
<i>Nerita albicilla</i>	Ga	+	+	0.1	4	–	–	60.0	20
<i>Batillaria zonalis</i>	Ga	–	–	50.0	80	–	–	–	–
<i>Clypeomorus bifasciata</i>	Ga	+	+	50.0	80	–	–	+	+
<i>Mictyris longicarpus</i>	De	–	–	6.0	8	–	–	–	–
Thalassinidae	De	–	–	3.6	4	–	–	–	–
<i>Septifer virgatus</i>	Bi	–	–	3.4	8	–	–	–	–
<i>Semele cordiformis</i>	Bi	–	–	3.2	4	–	–	–	–
<i>Suberites</i> sp.	Sp	–		2.1		–		–	
<i>Uca (Tubuca) dussumieri</i>	De	–	–	1.8	4	–	–	–	–
<i>Golfingia (Golfingia) elongata</i>	Si	–	–	0.1	4	–	–	1.0	20
<i>Thysanocardia catharinae</i>	Si	–	–	1.0	20	–	–	–	–
Grapsidae	De	–	–	–	–	–	–	1.0	20
<i>Tharyx</i> sp.	Po	–	–	–	–	–	–	0.8	100
<i>Leonnates persicus</i>	Po	–	–	–	–	–	–	0.6	60
<i>Trapezium bicarinatum</i>	Bi	–	–	0.6	4	–	–	–	–
<i>Phascolosoma (Phascolosoma) scolops</i>	Si	–	–	0.4	8	–	–	–	–
<i>Terebella ehrenbergi</i>	Po	–	–	0.2	4	–	–	–	–
<i>Tapes literatus</i>	Bi	–	–	0.2	4	–	–	–	–
<i>Arabella mutans</i>	Po	–	–	0.1	4	–	–	–	–
<i>Perinereis cultrifera</i>	Po	–	–	0.1	4	–	–	–	–
<i>Antillesoma antillarum</i>	Si	–	–	0.1	4	–	–	+	+
Priapulida	Pr	–	–	0.04	4	–	–	–	–
<i>Tellina diaphana</i>	Bi	–	–	0.04	2	–	–	–	–
<i>Onuphis eremita</i>	Po	–	–	0.04	2	–	–	–	–
<i>Bhawania cryptocephala</i>	Po	–	–	0.02	4	–	–	–	–
<i>Lysidice unicornis</i>	Po	–	–	0.02	4	–	–	–	–

Table 22 (Continued)

Taxa	Taxonomic group	Dao Trao Island				Danh Do La Island			
		Upper intertidal subzone		Middle intertidal subzone		Upper intertidal subzone		Middle intertidal subzone	
		B	N	B	N	B	N	B	N
Cumacea	Cu	–	–	0.02	2	–	–	–	–
<i>Lumbrineris shiinoi</i>	Po	–	–	0.02	2	–	–	–	–
Total biomass of animals		2733.0		879.5		430.0		1263.4	
Total biomass		2733.0		953.9		430.0		1263.4	

Leiosolenus levigatus, and others), sea anemones, mantis shrimps, hermit crabs and diverse brachyuran crabs, sipunculid worms, polychaetes (*Nereiphylla castanea*, *Heteromastus similis*, *Aphelochaeta multifilis*, and *Axiiothella* sp., and others), the fishes of the family Blenniidae, and other euryhaline inhabitants, able to tolerate estuarine environments, are found in the middle intertidal subzone.

The lower intertidal subzone is heavily silted, and macrobenthos is practically absent here. Only the plantlets of the red algae *Peyssonnelia* sp., *Bostrychia tenella*, and *Wurdemannia miniata* and the green alga *Cladophora papenfussii* occur at the entrance to the inlet on Dao Trao Island.



Fig. 16. In the intertidal zone of Danh Do La Island (Bai Tu Long Archipelago, Gulf of Tonkin).

Wave-exposed sandy beaches

Wave-exposed sandy beaches were studied on the Nam Du (Nam Du Archipelago), Sud, and Gio islets, Re and Cham islands, Hon Gom Peninsula (Cua Be Strait) and in Ro Bay (Table 1). These beaches are composed of clean, perfectly sorted sand, sometimes with fragments of dead corals, shells, and rare boulders. The intertidal zone is about 30–50 m wide. Wave action is almost permanent. The population is generally rather poor and uniform. These locations are either wholly devoid of macrobenthos or inhabited by mainly motile animals, which are difficult to count. The total biomass of macrobenthos is less than few hundred gWW m⁻². The macrobenthos is slightly richer in the lower intertidal subzone.

In the supratidal zone and the upper and middle intertidal subzones, brachyuran crabs (*Ocypode ceratophthalmus*, *O. convexa*, *Scopimera globosa*, and others) and hermit crabs (*Clibanarius ransonii*, *C. arethusa*, *C. longitarsus*, *Calcinus gaimardii*, *Dardanus deformis*, *Coenobita rugosus*, and others) prevail (Figs. 17, 18). In the middle intertidal subzone, Polychaeta and Amphipoda may be found. On Sud Islet, there is a belt of the green alga *Cladophora* sp.

In some of the studied locations, the species composition of the lower intertidal subzone is fairly diverse. On Sud Islet, there are typical belt-forming communities dominated by the seagrasses *Cymodocea rotundata* and *Thalassia hemprichii* jointly with the brown alga *Sargassum polycystum*. These communities also commonly include the brown alga *Lobophora variegata*, the red algae *Gracilaria canaliculata* and *G. coronopifolia*, the green alga *Halimeda macroloba*, and the seagrass *Halophila ovalis*. The biomass of plants reaches 645 gWW m⁻². Numerous and diverse sponges, isopods, echinoderms, and others group of invertebrates prevail among animals on Sud Islet.

On Re Island, boulders lying on the sand are abundantly covered with the red algae *Hypnea*, *Peyssonnelia*, *Laurencia*, *Asteromenia*, *Acanthophora*, *Amphiroa*, *Gracilaria*, and *Galaxaura*, the green algae *Ulva*, *Caulerpa*, *Chaetomorpha*, *Halimeda*, *Codium*,

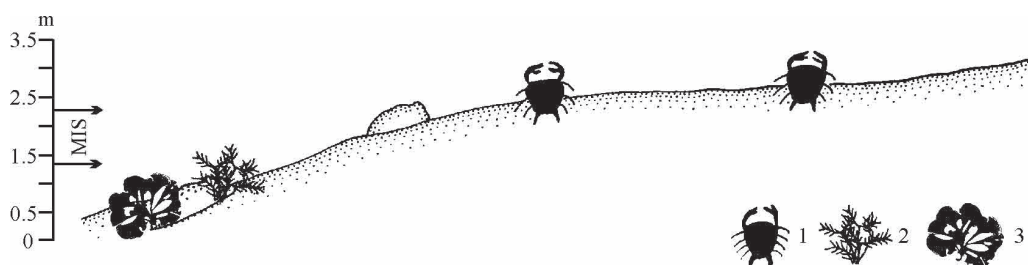


Fig. 17. Scheme of distribution of macrobenthos on wave-exposed sandy beach of Gio Islet. 1 – *Ocypode ceratophthalmus*, 2 – *Jania* sp., 3 – *Padina australis*. Vertical scale – range over depths 0. MIS – the middle intertidal subzone.



Fig. 18. Sandy beach in the south-western coast of Hon Gom Peninsula (Van Phong Bay). **A** – the general view, **B** – burrows of crabs at the upper border of the intertidal zone. Photograph by Alexey V. Chernyshev.

Neomeris, *Rhipidosiphon*, *Cladophora*, and *Dictyosphaeria*, the brown algae *Padina*, *Dictyota*, and the species of the genus *Sargassum*. The projective cover of the boulders by the algae is up to 100%. Animals of these communities include mainly the gastropods *Latirus barclayi*, *Pictocolumbella ocellata*, *Tenguella granulata*, *Clypeomorus bifasciata*, *Conus lividus*, *Trochus maculatus*, *Nerita albicilla*, and *Aplysia* sp., the bivalve mollusk *Pinctada margaritifera*, the sea urchins *Diadema setosum*, *Toxopneustes pileolus*, *Echinothrix diadema*, and *Tripneustes ventricosus*, the sea cucumber *Holothuria* (*Thymiosycia*) *impatiens*, the sponge *Suberites* sp., polychaetes *Leodice antennata* and *Loimia medusa*, the sipunculid worm *Phascolosoma* (*Phascolosoma*) *nigrescens*, amphipods, and the diverse crabs.

On Nam Du Islet, the macrobenthos is comprised of the gastropods *Pyramidella* sp., bivalve mollusks, polychaetes (up to 650 gWW m⁻²), and isopods; macrophyte algae are absent. On Cham Island, there are the alga *Padina australis* and the sea cucumber *H. (Th.) impatiens*. On Gio Islet, bushes of the algae *P. australis* and *Jania* sp. are found on rare boulders in the lower intertidal subzone (Fig. 17).

Tide pools

Tide pools are observed on hard substrata in a few locations (Petite Catwick, Thu and Lon islands, Rua (Nha Trang Bay) and Gio islets, Tien Sa Peninsula (the south-eastern part of the peninsula), Bai Tien Beach, and Cai Sung Bay) (Table 1). They are 2–7 m long and 0.2–1.5 m deep. The population of tide pools is generally poor. At Petite Catwick, a community of the gastropods *Dendropoma planorbis*+*Vermetus tokyoensis* inhabits perennial depositions of tubes of sedentary polychaetes. The oyster *Saccostrea scyphophilla* is also a prevailing species. The total animal biomass in the community is up to 5650 gWW m⁻². The bivalve mollusk *Isognomon ephippium* on Thu Island and *S. scyphophilla* on Tien Sa Peninsula form settlements on the walls of tide pools.

Some tide pools northward of Cape Lutin are characterized by a very diverse species composition of macrobenthos. The gastropods *Planaxis sulcatus* and *Echinolittorina millegrana* live on the walls of the tide pools, and the bottom is covered with calcareous red algae forming a 30–50% projective cover. The brown algae *Turbinaria ornata*, *Padina australis*, *Lobophora variegata*, *Sargassum* (plantlets), and the red alga *Asparagopsis taxiformis* are found here. There are also colonies of the zoanthid *Palythoa tuberculosa*, the holothurians *Holothuria* (*Semperothuria*) *cinerascens*, *H. (Thymiosycia) impatiens*, and *H. (Mertensiothuria) hilla*, the gastropods *Mancinella alouina*, *Cellana vitiensis*, *Nerita albicilla*, and others.

The constant presence of sea water, a specific feature of tide pools, creates favourable conditions for diverse fishes (*Terapon jarbua*, *Amblyglyphidodon curacao*,

Abudefduf saxatilis, *Labroides dimidiatus*, *Dascyllus* sp., *Pomacentrus* sp., *Istigobius* sp., and others) and invertebrates, which are typical both for the lower intertidal subzone and subtidal zone of Petite Catwick, Thu Island, Gio Islet, and Tien Sa Peninsula (for instance, the brittle stars *Ophiocoma erinaceus* and *Amphipholis squamata*).

In Cai Sung Bay, diverse and abundant bottom dwellers are observed in shallow, but quite large in area tide pools of a dead coral plateau. Two species of echinoderms (the large sea cucumber *Holothuria (Mertensiothuria) leucospilota* and the brittle star *Ophiocoma scolopendrina*) prevail here in numbers.

In tide pools of dead coral reefs on Bai Tien Beach, Lon Island, and Rua Islet, the gastropod species *Conus coronatus* and *Turbo bruneus* are often found under boulders. Among other numerous animals are bivalves (*Pinctada margaritifera*, *Isognomon isognomum*, *I. perna*, *Acar plicata*, *Chama pacifica*, *Rocellaria* sp., *Cardita variegata*, *Coralliophaga* sp., and others), sea anemones, sipunculid worms, sea cucumbers, brittle stars, and decapod crustaceans. The total biomass of animals is above 1470 gWW m⁻². Seagrass beds dominated by *Enhalus acoroides* and *Thalassia hemprichii* often cover the silty-sandy bottom of tide pools. Animals found in these beds include the gastropod *Drupella margariticola* and the bivalve mollusks *Arca ventricosa*, *Tellina carnicolor*, *Striarca symmetrica*, *Leiosolenus malaccanus*, and *Marteisia striata*. The total macrobenthic biomass is a little less than 2 kgWW m⁻².

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Appendix

The list of macrobenthos of the intertidal zone of Vietnam

Some groups have not been identified (sponges of Calcarea, Turbellaria, Priapulida, Cumacea, Tanaidacea, Mysidacea, and colonial ascidians) or are partly identified (calcareous algae, Actiniaria, Zoantharia, Sipuncula, Polychaeta, Amphipoda, Stomatopoda, Decapoda, Polyplacophora, Holothuroidea, Ophiuroidea, and fishes).

Locations: 1 – Gulf of Thailand, 2 – Mekong River mouth – Can Gio – Vung Tau, 3 – Catwick Islands, 4 – Thu Island, 5 – Cape Dinh – Ro Bay – O Loan Lagoon, 6 – Cape Ba Lang An – Re Island, 7 – Cham Island, 8 – Da Nang – Tien Sa Peninsula, 9 – Gio Islet, 10 – Gulf of Tonkin, 11 – location unknown; the sign «*» designates species found on Con Dao Islands.

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
PLANTS											
Phylum OCHROPHYTA											
Class PHAEOPHYCEAE											
Order DICTYOTALES											
Family Dictyotaceae											
<i>Dictyota dichotoma</i> (Hudson) J.V. Lamouroux				+	+						
<i>Dictyota friabilis</i> Setchell					+						
<i>Dictyota implexa</i> (Desfontaines) J.V. Lamouroux [= <i>D. divaricata</i>]			+	+	+				+		
<i>Dictyota mertensii</i> (Martius) Kützing											+
<i>Dictyota</i> spp.				+	+	+		+	+		
<i>Lobophora variegata</i> (J.V. Lamouroux) Womersley ex E.C. Oliveira [= <i>Pocockiella variegata</i>]	+		+	+	+	+	+	+	+		
<i>Lobophora</i> sp.					+						
<i>Padina australis</i> Hauck				+	+	+	+	+	+		
<i>Padina boryana</i> Thivy [= <i>P. commersonii</i> , <i>P. tenuis</i>]				+	+			+	+		
<i>Padina gymnospora</i> (Kützing) Sonder											+
<i>Padina</i> sp.					+						
Order ECTOCARPALES											
Family Acinetosporaceae											
<i>Feldmannia irregularis</i> (Kützing) Hamel					+						
<i>Feldmannia mitchelliae</i> (Harvey) H.-S. Kim [= <i>Giffordia mitchelliae</i>]					+						
Family Chordariaceae											
<i>Chilionema ocellatum</i> (Kützing) Kornmann					+						
<i>Kuetzingiella elachistaeformis</i> (Heydrich) M. Balakrishnan et Kinkar [= <i>Feldmannia elachistaeformis</i>]					+						
<i>Myrionema strangulans</i> Greville					+						
Family Scytosiphonaceae											
<i>Chnoospora implexa</i> J. Agardh					+						
<i>Chnoospora minima</i> (Hering) Papenfuss					+						
<i>Colpomenia sinuosa</i> (Mertens ex Roth) Derbès et Solier					+						
<i>Hydroclathrus clathratus</i> (C. Agardh) M. Howe				+	+						
<i>Hydroclathrus tenuis</i> C.K. Tseng et Lu					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Order FUCALES											
Family Sargassaceae											
<i>Hormophysa cuneiformis</i> (J.F. Gmelin) P.C. Silva [= <i>H. articulata</i>]						+					
<i>Polycladia</i> sp.					+						
<i>Sargassum aquifolium</i> (Turner) C. Agardh [= <i>S. binderi</i> , <i>S. crassifolium</i>]					+						
<i>Sargassum congkinhii</i> Pham-Hoàng Hô					+						
<i>Sargassum denticarpum</i> T. Ajisaka											+
<i>Sargassum feldmannii</i> Pham-Hoàng Hô				+	+						
<i>Sargassum hemiphyllum</i> (Turner) C. Agardh				+							
<i>Sargassum ilicifolium</i> (Turner) C. Agardh [= <i>S. cristaeifolium</i> , <i>S. duplicatum</i> , <i>S. sandei</i>]				+	+	+					
<i>Sargassum mclurei</i> Setchell				+	+						
<i>Sargassum miyabei</i> Yendo [= <i>S. kjellmanianum</i>]					+						
<i>Sargassum oligocystum</i> Montagne											+
<i>Sargassum polycystum</i> C. Agardh				+	+	+					
<i>Sargassum</i> spp.				+	+	+	+	+	+		
<i>Turbinaria conoides</i> (J. Agardh) Kützinger					+						
<i>Turbinaria decurrens</i> Bory	+										
<i>Turbinaria ornata</i> (Turner) J. Agardh	+				+	+	+	+			
Order RALFSIALES											
Family Neoralfsiaceae											
<i>Neoralfsia expansa</i> (J. Agardh) P.-E. Lim et H. Kawai ex Cormaci et G. Furnari [= <i>Ralfsia expansa</i>]	+		+		+			+			
Family Mesosporaceae											
<i>Mesospora schmidtii</i> Weber-van Bosse					+						
Order SCYTOTHAMNALES											
Family Asteronemataceae											
<i>Asteronema breviarticulatum</i> (J. Agardh) Ouriques et Bouzon [= <i>Feldmannia breviarticulata</i>]					+						
Order SPHACELARIALES											
Family Sphacelariaceae											
<i>Sphacelaria novae-hollandiae</i> Sonder					+						
<i>Sphacelaria rigidula</i> Kützinger [= <i>S. furcigera</i>]					+						
Phylum RHODOPHYTA											
Class BANGIOPHYCEAE											
Order BANGIALES											
Family Bangiaceae											
<i>Bangia fuscopurpurea</i> (Dillwyn) Lyngbye					+						
<i>Bangia tanakai</i> Pham-Hoàng Hô					+						
<i>Pyropia suborbiculata</i> (Kjellman) J.E. Sutherland, H.G. Choi, M.S. Hwang et W.A. Nelson [= <i>Porphyra suborbiculata</i>]					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Class COMPSOPOGONOPHYCEAE											
Order ERYTHROPELTIDALES											
Family Erythrotrichiaceae											
<i>Erythrotrichia parietalis</i> T. Tanaka					+						
Class FLORIDEOPHYCEAE											
Order ACROCHAETIALES											
Family Acrochaetiaceae											
<i>Acrochaetium catenulatum</i> M. Howe			+								
<i>Acrochaetium pulchellum</i> Børgesen					+						
<i>Acrochaetium robustum</i> Børgesen					+						
<i>Acrochaetium sancti-thomae</i> Børgesen					+						
<i>Acrochaetium</i> spp.			+		+						
Order BONNEMAISONIALES											
Family Bonnemaisoniaceae											
<i>Asparagopsis taxiformis</i> (Delile) Trevisan de Saint-Léon [= <i>Falkenbergia hillebrandii</i>]			+		+		+	+	+		
Order CERAMIALES											
Family Ceramiaceae											
<i>Centroceras clavulatum</i> (C. Agardh) Montagne	+			+	+	+					
<i>Centroceras gasparrinii</i> (Meneghini) Kützing [= <i>C. inerme</i>]					+						
<i>Ceramium cingulatum</i> Weber-van Bosse					+						
<i>Ceramium macilentum</i> J. Agardh [= <i>C. mazatlanense</i>]					+						
<i>Ceramium procumbens</i> Setchell et N.L. Gardner					+						
<i>Ceramium vietnamense</i> Pham-Hoàng Hô			+								
<i>Ceramium</i> sp.	+			+							
<i>Gayliella flaccida</i> (Harvey ex Kützing) T.O. Cho et L.J. McIvor [= <i>Ceramium gracillimum</i> f. <i>intermedium</i>]			+		+						
<i>Gayliella taylorii</i> (E.Y. Dawson) T.O. Cho et S.M. Boo [= <i>Ceramium taylorii</i>]					+						
Family Dasyaceae											
<i>Dasya anastomosans</i> (Weber-van Bosse) M.J. Wynne [= <i>Dasyopsis pilosa</i>]					+						
Family Delesseriaceae											
<i>Caloglossa bengalensis</i> (G. Martens) R.J. King et Puttock [= <i>C. adnata</i>]					+						
<i>Taenioma perpusillum</i> (J. Agardh) J. Agardh					+						
Family Rhodomelaceae											
<i>Acanthophora spicifera</i> (M. Vahl) Børgesen					+	+					
<i>Acrocystis nana</i> Zanardini			+		+						
<i>Amansia glomerata</i> C. Agardh [= <i>Melanamansia glomerata</i>]						+					
<i>Bostrychia binderi</i> Harvey										+	
<i>Bostrychia tenella</i> (J.V. Lamouroux) J. Agardh					+					+	
<i>Bryocladia cervicornis</i> (Kützing) F. Schmitz					+						
<i>Chondria repens</i> Børgesen					+						
<i>Chondrophyucus articulatus</i> (C.K. Tseng) K.W. Nam [= <i>Laurencia articulatus</i>]					+						
<i>Herposiphonia insidiosa</i> (Greville ex J. Agardh) Falkenberg					+						

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Herposiphonia secunda</i> var. <i>tenella</i> (C. Agardh) Ambrogn					+						
<i>Laurencia brachyclados</i> Pilger					+			+			
<i>Laurencia corymbosa</i> J. Agardh				+	+	+	+				
<i>Laurencia decumbens</i> Kützinger [= <i>L. pygmaea</i>]					+						
<i>Laurencia microcladia</i> Kützinger					+						
<i>Laurencia obtusa</i> (Hudson) J.V. Lamouroux	+										
<i>Laurencia obtusa</i> var. <i>densa</i> Yamada					+						
<i>Laurencia tenera</i> C.K. Tseng					+						
<i>Laurencia tropica</i> Yamada					+	+					
<i>Laurencia</i> spp.	+			+		+					
<i>Leveillea jungermannioides</i> (Hering et G. Martens) Harvey	+				+						
<i>Neosiphonia harlandii</i> (Harvey) M.S. Kim et I.K. Lee						+					
<i>Palisada concreta</i> (A.B. Cribb) K.W. Nam [= <i>Chondrophycus concretus</i>]					+						
<i>Palisada parvipapillata</i> (C.K. Tseng) K.W. Nam [= <i>Chondrophycus parvipapillatus</i> , <i>Laurencia parvipapillata</i>]				+	+			+			
* <i>Palisada perforata</i> (Bory) K.W. Nam [= <i>P. papillosa</i> , <i>Laurencia papillosa</i> , <i>L. perforata</i>]					+	+	+				
<i>Palisada thuyoides</i> (Kützinger) Cassano, Senties, Gil-Rodríguez et M.T. Fujii [= <i>Laurencia paniculata</i>]					+						
<i>Polysiphonia coacta</i> C.K. Tseng					+						
<i>Polysiphonia fragilis</i> Suringar					+						
<i>Polysiphonia subtilissima</i> Montagne					+						
<i>Polysiphonia</i> spp.	+		+		+						
<i>Tolypocladia glomerulata</i> (C. Agardh) F. Schmitz					+						
<i>Tolypocladia</i> sp.					+						
Family Spyridiaceae											
<i>Spyridia filamentosa</i> (Wulfen) Harvey					+						
Family Wrangeliaceae											
<i>Anotrichium tenue</i> (C. Agardh) Nägeli [= <i>Griffithsia tenuis</i>]					+						
<i>Griffithsia japonica</i> Okamura											+
<i>Griffithsia metcalfii</i> C.K. Tseng					+						
<i>Spongoconium caribaeum</i> (Børgesen) M.J. Wynne [= <i>Mesothamnion caribaeum</i>]					+						
<i>Wrangelia argus</i> (Montagne)					+						
Order COLACONEMATALES											
Family Colaconemataceae											
<i>Colaconema gracile</i> (Børgesen) Ateweberhan et Prud'homme van Reine [= <i>Acrochaetium gracile</i>]					+						
Order CORALLINALES											
Family Corallinaceae											
<i>Amphiroa foliacea</i> J.V. Lamouroux					+						
<i>Amphiroa fragilissima</i> (Linnaeus) J.V. Lamouroux	+				+						
<i>Amphiroa</i> spp.						+		+	+		
<i>Hydrolithon farinosum</i> (J.V. Lamouroux) Penrose et Y.M. Chamberlain [= <i>Melobesia farinosa</i> , <i>Fosliella farinosa</i>]					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Hydrolithon reinboldii</i> (Weber-van Bosse et Foslie) Foslie					+						
<i>Hydrolithon samoëense</i> (Foslie) Keats et Y.M. Chamberlain [= <i>Lithophyllum samoëense</i>]					+						
<i>Hydrolithon</i> sp.					+						
<i>Jania acutiloba</i> (Decaisne) J.H. Kim, Guiry et H.-G. Choi [= <i>Cheilosporum jungermannioides</i>]					+						
<i>Jania adhaerens</i> J.V. Lamouroux [= <i>J. decussato-dichotoma</i>]					+						
<i>Jania capillacea</i> Harvey					+						
<i>Jania pumila</i> J.V. Lamouroux			+								
<i>Jania rubens</i> (Linnaeus) J.V. Lamouroux					+						
<i>Jania spectabilis</i> (Harvey ex Grunow) J.H. Kim, Guiry et H.-G. Choi [= <i>Cheilosporum spectabile</i>]	+										
<i>Jania</i> spp.			+	+	+			+	+		
<i>Lithophyllum okamurae</i> Foslie				+	+	+		+			
<i>Lithophyllum</i> sp.					+						
<i>Mastophora pacifica</i> (Heydrich) Foslie [= <i>Lithoporella pacifica</i>]					+						
<i>Mastophora rosea</i> (C. Agardh) Setchell [= <i>M. macrocarpa</i>]				+	+						
<i>Neogoniolithon oblimans</i> (Heydrich) P.C. Silva [= <i>N. myriocarpum</i>]					+						
<i>Neogoniolithon trichotomum</i> (Heydrich) Setchell et L.R. Mason [= <i>Lithophyllum trichotomum</i>]					+						
Order GELIDIALES											
Family Gelidiaceae											
<i>Gelidiophycus divaricatus</i> (G. Martens) G.H. Boo, J.K. Park et S.M. Boo [= <i>Gelidium divaricatum</i>]					+						
<i>Gelidium crinale</i> (Hare ex Turner) Gaillon	+		+		+		+	+			
<i>Gelidium crinale</i> var. <i>perpusillum</i> Piccone et Grunow					+						
<i>Gelidium pulchellum</i> (Turner) Kützing					+						
<i>Gelidium pusillum</i> (Stackhouse) Le Jolis	+				+						
<i>Gelidium spathulatum</i> (Kützing) Bornet					+						
<i>Gelidium</i> spp.			+	+	+			+	+	+	
Family Gelidiellaceae											
<i>Gelidiella acerosa</i> (Forsskål) Feldmann et Hamel			+	+	+			+			
<i>Gelidiella lubrica</i> (Kützing) Feldmann et Hamel					+						
<i>Gelidiella myrioclada</i> (Børgesen) Feldmann et Hamel			+		+						
<i>Gelidiella</i> sp.	+										
<i>Parviphyicus adnatus</i> (E.Y. Dawson) B. Santelices [= <i>Gelidiella adnata</i>]					+						
Family Pterocladiaceae											
<i>Pterocladiella caloglossoides</i> (M. Howe) Santelices [= <i>Pterocladia parva</i>]					+						
Order GIGARTINALES											
Family Gigartinaceae											
<i>Chondracanthus intermedius</i> (Suringar) Hommersand											+
Family Caulacanthaceae											
<i>Catenella nipae</i> Zanardini					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Cystocloniaceae											
<i>Hypnea aspera</i> Kützinger [= <i>H. boergesenii</i>]	+				+						
<i>Hypnea cervicornis</i> J. Agardh					+	+					
<i>Hypnea esperi</i> Bory (<i>nomen illegitimum</i>)	+		+		+						
<i>Hypnea nidulans</i> Setchell			+					+			
<i>Hypnea pannosa</i> J. Agardh			+		+			+			
<i>Hypnea valentiae</i> (Turner) Montagne					+	+					
<i>Hypnea</i> sp.						+					
Family Phylloporaceae											
<i>Abnfeltiopsis flabelliformis</i> (Harvey) Masuda [= <i>Gymnogongrus flabelliformis</i>]					+						
<i>Abnfeltiopsis pygmaea</i> (J. Agardh) P.C. Silva et DeCew [= <i>Gymnogongrus pygmaeus</i>]					+						
<i>Abnfeltiopsis quinhonensis</i> (Pham-Hoàng Hô) Masuda [= <i>Gymnogongrus quinhonensis</i>]			+								
<i>Abnfeltiopsis serenei</i> (E.Y. Dawson) Masuda [= <i>Gymnogongrus serenei</i>]					+						
<i>Gymnogongrus griffithsiae</i> (Turner) Martius			+		+						
<i>Gymnogongrus</i> sp.								+			
Family Solieriaceae											
<i>Kappaphycus alvarezii</i> (Doty) Doty ex P.C. Silva											+
<i>Wurde mannia miniata</i> (Sprengel) Feldmann et Hamel										+	
Order GRACILARIALES											
Family Gracilariaceae											
<i>Gracilaria arcuata</i> Zanardini					+	+					
<i>Gracilaria blodgettii</i> Harvey											+
<i>Gracilaria bursa-pastoris</i> (S.G. Gmelin) P.C. Silva						+					
<i>Gracilaria canaliculata</i> Sonder [= <i>G. crassa</i>]				+	+	+					
<i>Gracilaria coronopifolia</i> J. Agardh				+		+					
<i>Gracilaria edulis</i> (S.G. Gmelin) P.C. Silva											+
<i>Gracilaria eucheumatoides</i> Harvey [= <i>Hydropuntia eucheumatoides</i>]						+					
<i>Gracilaria reptans</i> (Weber-van Bosse) P.C. Silva					+						
<i>Gracilaria salicornia</i> (C. Agardh) E.Y. Dawson						+					
<i>Gracilaria spinulosa</i> (Okamura) C.F. Chang et B.M. Xia											+
<i>Gracilaria tenuistipitata</i> C.F. Chang et B.M. Xia					+						
<i>Gracilaria vermiculophylla</i> (Ohmi) Papenfuss											+
Order HALYMENIALES											
Family Halymeniaceae											
<i>Grateloupia asiatica</i> S. Kawaguchi et H.W. Wang					+						
<i>Grateloupia filicina</i> (J.V. Lamouroux) C. Agardh					+						
<i>Grateloupia ramosissima</i> Okamura					+						
<i>Halymenia dilatata</i> Zanardini					+						
<i>Halymenia maculata</i> J. Agardh					+						
<i>Yonagunia formosana</i> (Okamura) Kawaguchi et Masuda [= <i>Carpopeltis formosana</i>]					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Order HAPALIDIALES											
Family Hapalidiaceae											
<i>Lithothamnion</i> spp.			+		+		+	+	+	+	
<i>Melyvonnea erubescens</i> (Foslie) Athanasiadis et D.L. Ballantine [= <i>Lithothamnion erubescens</i>]				+	+						
Order HILDENBRANDIALES											
Family Hildenbrandiaceae											
<i>Hildenbrandia rubra</i> (Sommerfelt) Meneghini [= <i>H. prototypus</i>]					+						
<i>Hildenbrandia</i> sp.					+						
Order NEMALIALES											
Family Galaxauraceae											
<i>Dichotomaria marginata</i> (J. Ellis et Solander) Lamarck [= <i>Galaxaura clavigera</i> , <i>G. marginata</i>]						+		+			
<i>Galaxaura divaricata</i> (Linnaeus) Huisman et R.A. Townsend [= <i>G. fasciculata</i>]					+						
<i>Galaxaura filamentosa</i> R.C.Y. Chou					+						
<i>Galaxaura rugosa</i> (J. Ellis et Solander) J.V. Lamouroux [= <i>G. glabriuscula</i>]						+	+	+	+		
<i>Tricleocarpa cylindrica</i> (J. Ellis et Solander) Huisman et Borowitzka [= <i>Galaxaura fastigiata</i>]					+	+					
Family Liagoraceae											
<i>Dermonea virens</i> (J. Agardh) Pedroche et Ávila Ortiz [= <i>D. frapperi</i>]					+						
<i>Ganonema farinosum</i> (J.V. Lamouroux) K.C. Fan et Yung C. Wang [= <i>Liagora farinosa</i>]					+						
<i>Izziella orientalis</i> (J. Agardh) Huisman et Schils [= <i>Liagora orientalis</i>]					+						
<i>Liagora ceranoides</i> J.V. Lamouroux					+						
<i>Liagora</i> spp.			+			+					
Order NEMASTOMATALES											
Family Schizymeniaceae											
<i>Titanophora weberae</i> Børgesen [= <i>T. pulchra</i>]					+						
Order PEYSSONNELIALES											
Family Peyssonneliaceae											
<i>Peyssonnelia rubra</i> (Greville) J. Agardh					+						
<i>Peyssonnelia</i> spp.			+		+	+	+	+	+	+	+
<i>Ramicrusta calcea</i> (Heydrich) K.R. Dixon [= <i>Peyssonnelia calcea</i>]					+						
<i>Sonderophycus capensis</i> (Montagne) M.J. Wynne [= <i>Peyssonnelia gunniana</i>]					+						
Order RHODYMENIALES											
Family Champiaceae											
<i>Champia parvula</i> (C. Agardh) Harvey			+		+						
<i>Champia vieillardii</i> Kützing					+						
Family Hymenocladaceae											
<i>Asteromenia anastomosans</i> (Weber-van Bosse) G.W. Saunders, C.E. Lane, C.W. Schneider et Kraft [= <i>Rhodymenia anastomosans</i>]			+	+	+	+					

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Lomentariaceae											
<i>Ceratodictyon intricatum</i> (C. Agardh) R.E. Norris [= <i>Gelidiopsis intricata</i>]	+				+						
<i>Ceratodictyon repens</i> (Kützinger) R.E. Norris [= <i>Gelidiopsis repens</i>]			+						+		
<i>Ceratodictyon scoparium</i> (Montagne et Millardet) R.E. Norris [= <i>Gelidiopsis scoparia</i>]			+						+		
<i>Ceratodictyon spongiosum</i> Zanardini					+	+					
Phylum CHLOROPHYTA											
Class ULVOPHYCEAE											
Order BRYOPSIDALES											
Family Bryopsidaceae											
<i>Bryopsis pennata</i> J.V. Lamouroux				+							
Family Caulerpaceae											
<i>Caulerpa chemnitzia</i> (Esper) J.V. Lamouroux [= <i>C. peltata</i>]											+
<i>Caulerpa fastigiata</i> Montagne				+	+	+					
<i>Caulerpa lentillifera</i> J. Agardh						+					
<i>Caulerpa macrodisca</i> Decaisne [= <i>C. peltata</i> var. <i>macrodisca</i>]									+		
<i>Caulerpa mexicana</i> Sonder ex Kützinger						+					
<i>Caulerpa microphysa</i> (Weber-van Bosse) Feldmann					+			+	+		
<i>Caulerpa nummularia</i> Harvey ex J. Agardh											+
<i>Caulerpa racemosa</i> (Forsskål) J. Agardh			+	+	+	+			+		
<i>Caulerpa serrulata</i> (Forsskål) J. Agardh			+	+	+						
<i>Caulerpa sertularioides</i> (S.G. Gmelin) M. Howe			+	+							
<i>Caulerpa taxifolia</i> (M. Vahl) C. Agardh			+	+	+				+		
<i>Caulerpa verticillata</i> J. Agardh					+						
<i>Caulerpella ambigua</i> (Okamura) Prud'homme van Reine et Lokhorst					+						
Family Codiaceae											
<i>Codium arabicum</i> Kützinger						+					
<i>Codium geppiorum</i> O.C. Schmidt [as <i>C. geppii</i>]					+						
<i>Codium repens</i> P. Crouan et H. Crouan								+	+	+	
Family Derbesiaceae											
<i>Halicystis pyriformis</i> Levring					+						
Family Dichotomosiphonaceae											
<i>Avrainvillea erecta</i> (Berkeley) A. Gepp et E.S. Gepp					+						
Family Halimedaceae											
<i>Halimeda bikinensis</i> W.R. Taylor				+							
<i>Halimeda cuneata</i> Hering					+						
<i>Halimeda discoidea</i> Decaisne				+	+	+					
<i>Halimeda maculosa</i> Decaisne				+	+						
<i>Halimeda opuntia</i> (Linnaeus) J.V. Lamouroux				+	+	+					
<i>Halimeda tuna</i> (J. Ellis et Solander) J.V. Lamouroux					+						
Family Udoteaceae											
<i>Chlorodesmis hildebrandtii</i> A. Gepp et E.S. Gepp			+								
<i>Penicillus sibogae</i> A. Gepp et E.S. Gepp					+						
<i>Rhipidosiphon javensis</i> Montagne [= <i>Udotea javensis</i>]					+	+					

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Order CLADOPHORALES											
Family Cladophoraceae											
<i>Chaetomorpha antennina</i> (Bory) Kützing					+						
<i>Chaetomorpha indica</i> (Kützing) Kützing					+						
<i>Chaetomorpha javanica</i> Kützing					+						
<i>Chaetomorpha linum</i> (O.F. Müller) Kützing [= <i>Ch. crassa</i>]						+					
<i>Cladophora albida</i> (Nees) Kützing					+						
<i>Cladophora catenata</i> Kützing				+							
<i>Cladophora herpestica</i> (Montagne) Kützing [= <i>Cladophoropsis herpestica</i>]					+						
<i>Cladophora laetevirens</i> (Dillwyn) Kützing					+						
<i>Cladophora papenfussii</i> Pham-Hoàng Hô										+	
<i>Cladophora perpusilla</i> Skottsberg et Levring					+						
<i>Cladophora vagabunda</i> (Linnaeus) Hoek [= <i>C. inserta</i>]					+						
<i>Cladophora</i> spp.			+	+	+	+				+	
<i>Rhizoclonium grande</i> Børgesen					+						
<i>Rhizoclonium riparium</i> (Roth) Harvey [= <i>Rh. kernerii</i>]					+						
Family Anadyomenaceae											
<i>Anadyomene plicata</i> C. Agardh					+	+					
<i>Anadyomene wrightii</i> Harvey ex J.E. Gray					+						
Family Boodleaceae											
<i>Boodlea composita</i> (Harvey) F. Brand					+						
<i>Boodlea struveoides</i> M. Howe				+	+						
<i>Cladophoropsis membranacea</i> (Hofman Bang ex C. Agardh) Børgesen					+						
<i>Cladophoropsis sundanensis</i> Reinbold				+	+						
<i>Phyllodictyon anastomosans</i> (Harvey) Kraft et M.J. Wynne [= <i>Struvea delicatula</i> , <i>S. anastomosans</i>]					+		+				
Family Siphonocladaceae											
<i>Boergesenia forbesii</i> (Harvey) Feldmann					+	+					
<i>Dictyosphaeria cavernosa</i> (Forsskål) Børgesen			+	+	+	+	+	+	+		
<i>Dictyosphaeria versluysii</i> Weber-van Bosse [= <i>D. setchellii</i>]			+		+	+				+	
Family Valoniaceae											
<i>Valonia aegagropila</i> C. Agardh					+						
<i>Valonia fastigiata</i> Harvey ex J. Agardh						+					
<i>Valonia ventricosa</i> J. Agardh					+						
<i>Valonia</i> sp.				+	+						
<i>Valoniopsis pachynema</i> (G. Martens) Børgesen			+					+			
Order DASYCLADALES											
Family Dasycladaceae											
<i>Bornetella oligospora</i> Solms-Laubach					+						
<i>Bornetella sphaerica</i> (Zanardini) Solms-Laubach					+						
<i>Neomeris annulata</i> Dickie					+			+	+		
<i>Neomeris vanbosseae</i> M. Howe						+					

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Order ULOTRICHALES											
Family Monostromataceae											
<i>Monostroma nitidum</i> Wittrock [= <i>Porphyra crispata</i>]					+						
<i>Monostroma</i> sp.					+						
Order ULVALES											
Family Ulvaceae											
<i>Ulva clathrata</i> (Roth) C. Agardh [= <i>Enteromorpha clathrata</i>]					+						
<i>Ulva flexuosa</i> Wulfen [= <i>Enteromorpha tubulosa</i>]					+						
<i>Ulva intestinalis</i> Linnaeus [= <i>Enteromorpha intestinalis</i>]					+						
<i>Ulva kylinii</i> (Bliding) H.S. Hayden, Blomster, Maggs, P.C. Silva, M.J. Stanhope et J.R. Waaland					+						
[= <i>Enteromorpha kylinii</i>]											
<i>Ulva lactuca</i> Linnaeus					+	+					
<i>Ulva reticulata</i> Forsskål					+		+				
<i>Ulva</i> spp. [= <i>Enteromorpha</i> sp.]		+			+		+				
Family Ulvellaceae											
<i>Ulvella viridis</i> (Reinke) R. Nielsen, C.J. O'Kelly et B. Wysox [= <i>Entocladia viridis</i>]					+						
Phylum TRACHEOPHYTA											
Class MONOCOTS											
Order ALISMATALES											
Family Hydrocharitaceae											
<i>Enhalus acoroides</i> (Linnaeus) Royle					+						
<i>Halophila beccarii</i> Ascherson					+					+	
<i>Halophila ovalis</i> (R. Brown) J.D. Hooker				+						+	
<i>Halophila ovata</i> Gaudichaud					+						
<i>Halophila</i> sp.										+	
<i>Thalassia hemprichii</i> (Ehrenberg) Ascherson				+	+	+					
<i>Thalassia</i> spp.				+	+	+		+			
Family Cymodoceaceae											
<i>Cymodocea rotundata</i> Ascherson et Schweinfurth				+	+						
<i>Cymodocea</i> sp.										+	
<i>Halodule pinifolia</i> (Miki) den Hartog					+						
<i>Halodule uninervis</i> (Forsskål) Ascherson					+					+	
[= <i>H. tridentata</i> , <i>Diplanthera uninervis</i>]											
ANIMALS											
Phylum PORIFERA (=SPONGIA)											
Class DEMOSPONGIAE											
Order TETRACTINELLIDA											
Family Geodiidae											
<i>Geodia</i> spp.				+	+						
Family Tetillidae											
<i>Cinachyrella australiensis</i> (Carter, 1886)					+						
[= <i>Cinachyra australiensis</i>]											
Order CLIONAIDA											
Family Placospongiidae											
<i>Placospongia carinata</i> (Bowerbank, 1858)					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Spirastrellidae											
<i>Spirastrella</i> sp.						+					
Order SUBERITIDA											
Family Suberitidae											
<i>Aaptos suberitoides</i> (Brøndsted, 1934) [= <i>A. aaptos</i> var. <i>nigra</i>]					+						
<i>Pseudosuberites lobulatus</i> (Lévi, 1961)					+						
<i>Suberites</i> spp.			+		+	+				+	
Family Halichondriidae											
<i>Amorphinopsis foetida</i> (Dendy, 1889)					+						
<i>Halichondria</i> (<i>Halichondria</i>) <i>cartilaginea</i> (Esper, 1794)					+						
[= <i>H. symbiotica</i>]					+						
<i>Halichondria</i> spp.			+		+						
Order TETHYIDA											
Family Tethyidae											
<i>Tethya japonica</i> Sollas, 1888										+	
<i>Xenospongia patelliformis</i> Gray, 1858					+						
Family Timeidae											
<i>Timea</i> sp.										+	
Order SCOPALINIDA											
Family Scopalinidae											
<i>Stylissa carteri</i> (Dendy, 1889) [= <i>Acanthella aurantiaca</i>]					+						
<i>Stylissa flexibilis</i> (Lévi, 1961) [= <i>Ptilocaulis flexibilis</i>]					+						
<i>Stylissa</i> sp.					+						
Order POECILOSCLERIDA											
Family Desmacididae											
<i>Desmapsamma anchorata</i> (Carter, 1882) [= <i>Desmacidon reptans</i>]					+						
Family Microcionidae											
<i>Clathria</i> (<i>Thalysias</i>) <i>erecta</i> (Thiele, 1899)					+	+					
[= <i>Rhaphidophylus erectus</i>]											
<i>Clathria</i> (<i>Thalysias</i>) <i>ramosa</i> (Kieschnick, 1896)			+								
<i>Clathria</i> sp.					+						
<i>Ophlitaspongia</i> sp.					+						
Family Mycalidae											
<i>Mycale</i> (<i>Aegogropila</i>) <i>crassissima</i> (Dendy, 1905)					+						
<i>Mycale</i> (<i>Carmia</i>) <i>phyllophila</i> Hentschel, 1911					+						
Family Tedaniidae											
<i>Tedania</i> (<i>Tedania</i>) <i>anbelans</i> (Vio in Olivi, 1792) [= <i>T. digitata</i>]			+								
<i>Tedania</i> (<i>Tedania</i>) <i>brevispiculata</i> Thiele, 1903					+						
Order BIEMNIDA											
Family Biemnidae											
<i>Biemna fortis</i> (Topsent, 1897)					+						
Family Rhabderemiidae											
<i>Rhabderemia</i> sp. [as <i>Rb. conulosa</i>]					+						
Order AXINELLIDA											
Family Raspailiidae											
<i>Raspailia</i> sp.						+					

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Order HAPLOSCLERIDA											
Family Callyspongiidae											
<i>Callyspongia</i> (<i>Callyspongia</i>) <i>monilata</i> (Ridley, 1884) [= <i>Dactylochalina monilata</i>]					+						
<i>Callyspongia</i> (<i>Cladochalina</i>) <i>fibrosa</i> (Ridley et Dendy, 1886)					+						
<i>Callyspongia</i> (<i>Toxochalina</i>) <i>robusta</i> (Ridley, 1884)					+						
<i>Callyspongia</i> sp.						+					
Family Chalinidae											
<i>Haliclona</i> (<i>Gellius</i>) <i>amboinensis</i> (Lévi, 1961) [= <i>Gellius amboinensis</i>]					+						
<i>Haliclona</i> (<i>Gellius</i>) <i>cymaeformis</i> (Esper, 1794) [= <i>Gellius cymaeformis</i>]					+						
<i>Haliclona</i> (<i>Gellius</i>) <i>ridleyi</i> (Hentschel, 1912) [= <i>Gellius ridleyi</i>]					+						
<i>Haliclona</i> spp. [= <i>Gellius</i> sp.]			+		+			+			
Family Niphatidae											
<i>Amphimedon</i> spp.						+		+	+		
<i>Gelliodes callista</i> de Laubenfels, 1954					+						
<i>Gelliodes fibulata</i> (Carter, 1881)					+						
<i>Gelliodes</i> spp.			+			+	+		+		
Family Petrosiidae											
<i>Petrosia</i> sp.								+			
Order DICTYOCERATIDA											
Family Spongiidae											
<i>Spongia</i> (<i>Spongia</i>) <i>officinalis</i> Linnaeus, 1759					+						
<i>Spongia</i> sp.			+								
Family Thorectidae											
<i>Fasciospongia turgida</i> (Lamarck, 1814) [= <i>Polyfibrospongia australis</i>]					+						
Family Dysideidae											
<i>Dysidea</i> sp.					+						
Order CHONDRILLIDA											
Family Chondrillidae											
<i>Chondrilla australiensis</i> Carter, 1873 [= <i>Chondrillastra australiensis</i>]					+						
Phylum CNIDARIA											
Class HYDROZOA											
Order LEPTOTHECATA											
Family Aglaopheniidae											
<i>Aglaophenia cupressina</i> Lamouroux, 1816					+						
<i>Macrorhynchia philippina</i> Kirchenpauer, 1872 [= <i>Lytocarpus philippinus</i>]					+						
Family Halopterididae											
<i>Schizotricha</i> sp.			+								
Family Sertulariidae											
<i>Dynamena crisioides</i> Lamouroux, 1824 [= <i>D. tubuliformis</i>]					+						
<i>Sertularella</i> sp.			+								
<i>Sertularia</i> sp.			+								

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Order ANTHOATHECATA											
Family Milleporidae											
<i>Millepora dichotoma</i> var. <i>dichotoma</i> (Forsskål, 1775) [= <i>M. dichotoma</i>]					+	+					
<i>Millepora dichotoma</i> var. <i>intricata</i> (Milne Edwards, 1860) [= <i>M. intricata</i>]					+						
<i>Millepora dichotoma</i> var. <i>tenera</i> (Boschma, 1949) [= <i>M. tenera</i> , <i>M. tenella</i>]					+						
<i>Millepora platyphylla</i> Hemprich et Ehrenberg, 1834	+			+	+						
Family Oceaniidae											
<i>Corydendrium parasiticum</i> (Linnaeus, 1767)					+						
Family Pennariidae											
<i>Pennaria disticha</i> Goldfuss, 1820 [= <i>Halocordyle disticha</i>]					+						
Class ANTHOZOA											
Order ACTINIARIA											
Family Halcampoididae											
<i>Halcampella maxima</i> Hertwig, 1888										+	
Family Actiniidae											
<i>Anemonia</i> sp.					+						
* <i>Entacmaea quadricolor</i> (Leuckart in Rüppell et Leuckart, 1828)					+		+			+	
<i>Gyrostoma</i> sp.						+					
Family Stichodactylidae											
<i>Heteractis aurora</i> (Quoy et Gaimard, 1833)					+						
<i>Heteractis malu</i> (Haddon et Shackleton, 1893)					+						
<i>Stichodactyla gigantea</i> (Forsskål, 1775) [= <i>Stoichactis kenti</i>]					+						
Family Diadumenidae											
<i>Diadumene lineata</i> (Verrill, 1869) [= <i>Haliplanella luciae</i>]										+	
Family Sagartiidae											
* <i>Sagartianthus indosinensis</i> Carlgren, 1943											
Order SCLERACTINIA											
Family Acroporidae											
<i>Acropora abrotanoides</i> (Lamarck, 1816) [= <i>A. rotumana</i> , <i>A. danai</i>] +					+						
<i>Acropora aspera</i> (Dana, 1846)					+						
* <i>Acropora cytherea</i> (Dana, 1846)					+	+		+			
<i>Acropora digitifera</i> (Dana, 1846)					+	+					
<i>Acropora divaricata</i> (Dana, 1846)					+						
* <i>Acropora florida</i> (Dana, 1846)					+						
<i>Acropora formosa</i> (Dana, 1846)					+						
<i>Acropora gemmifera</i> (Brook, 1892)					+						
<i>Acropora humilis</i> (Dana, 1846)					+						
* <i>Acropora hyacinthus</i> (Dana, 1846)					+	+		+			
<i>Acropora millepora</i> (Ehrenberg, 1834)	+				+						
<i>Acropora muricata</i> (Linnaeus, 1758) [= <i>A. arbuscula</i>]					+						
<i>Acropora robusta</i> (Dana, 1846)	+				+	+		+			
<i>Acropora secale</i> (Studer, 1878) [= <i>A. concinna</i> , <i>A. diversa</i>]					+						

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Acropora subulata</i> (Dana, 1846)					+						
<i>Acropora tenuis</i> (Dana, 1846)					+						
<i>Acropora</i> spp. [as <i>A. tubicinarina</i>]					+		+				
<i>Astreopora listeri</i> Bernard, 1896					+						
<i>Astreopora myriophthalma</i> (Lamarck, 1816)					+						
<i>Isopora palifera</i> (Lamarck, 1816) [= <i>Acropora palifera</i>]					+						
<i>Montipora angulata</i> (Lamarck, 1816) [= <i>M. ramosa</i>]					+						
<i>Montipora caliculata</i> (Dana, 1846)					+						
<i>Montipora compressa</i> (Linnaeus, 1766) (<i>nomen dubium</i>) [as <i>Acropora compressa</i>]					+						
<i>Montipora digitata</i> (Dana, 1846)				+							
<i>Montipora efflorescens</i> Bernard, 1897					+						
<i>Montipora foliosa</i> (Pallas, 1766) [as <i>M. prolifera</i>]					+						
* <i>Montipora hispida</i> (Dana, 1846)	+			+							
<i>Montipora informis</i> Bernard, 1897					+						
<i>Montipora monasteriata</i> (Forskål, 1775)					+						
<i>Montipora spongodes</i> Bernard, 1897				+							
<i>Montipora stellata</i> Bernard, 1897 [= <i>M. solanderi</i>]					+						
<i>Montipora studeri</i> Vaughan, 1907 (<i>nomen dubium</i>) [as <i>Acropora studeri</i>]					+						
<i>Montipora turtlensis</i> Veron et Wallace, 1984					+						
<i>Montipora</i> sp.					+						
Family Agariciidae											
<i>Gardineroseris pavonoides</i> Latypov, 2011 (<i>nomen nudum</i>)					+						
<i>Leptoseris mycetoseroides</i> Wells, 1954				+							
<i>Pachyseris speciosa</i> (Dana, 1846)					+						
* <i>Pavona decussata</i> (Dana, 1846) [= <i>P. crassa</i> , <i>P. lata</i>]				+	+						
<i>Pavona frondifera</i> (Lamarck, 1816)					+						
<i>Pavona varians</i> Verrill, 1864					+						
Family Dendrophylliidae											
<i>Balanophyllia</i> (<i>Balanophyllia</i>) <i>gemmifera</i> Klunzinger, 1879				+							
<i>Cladopsammia gracilis</i> (Milne Edwards et Haime, 1848) [= <i>Dendrophyllia gracilis</i>]				+							
<i>Dendrophyllia</i> sp.					+						
<i>Tubastraea coccinea</i> Lesson, 1829			+								
<i>Turbinaria calicularis</i> Bernard, 1896 (<i>nomen dubium</i>)					+						
<i>Turbinaria contorta</i> Bernard, 1896					+						
<i>Turbinaria crater</i> (Pallas, 1766) (<i>nomen dubium</i>)					+						
<i>Turbinaria mollis</i> Bernard, 1896 (<i>nomen dubium</i>)					+						
<i>Turbinaria peltata</i> (Esper, 1794)					+						
Family Oculinidae											
<i>Galaxea astreata</i> (Lamarck, 1816) [= <i>G. clavus</i>]					+						
<i>Galaxea fascicularis</i> (Linnaeus, 1767)	+				+						
<i>Galaxea</i> sp.							+				

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Fungiidae											
<i>Ctenactis echinata</i> (Pallas, 1766) [= <i>Fungia echinata</i>]					+						
<i>Fungia concinna</i> Verrill, 1864					+						
<i>Fungia fungites</i> (Linnaeus, 1758)					+						
<i>Fungia repanda</i> Dana, 1846					+						
<i>Fungia scutaria</i> Lamarck, 1801					+						
<i>Herpolitha limax</i> (Esper, 1797)					+						
<i>Pleuractis paumotensis</i> (Stutchbury, 1833)					+						
<i>Podabacia crustacea</i> (Pallas, 1766)					+						
<i>Polyphyllia talpina</i> (Lamarck, 1801)					+						
<i>Sandalolitha robusta</i> (Quelch, 1886)					+						
Family Mussidae											
<i>Acanthastrea echinata</i> (Dana, 1846) [= <i>A. spinosa</i>]					+						
<i>Lobophyllia hemprichii</i> (Ehrenberg, 1834)					+						
<i>Lobophyllia robusta</i> Yabe et Sugiyama, 1936					+						
<i>Symphyllia recta</i> (Dana, 1846) [= <i>S. nobilis</i>]					+						
<i>Symphyllia sinuosa</i> (Quoy et Gaimard, 1833) [as <i>Meandrina sinuosa</i>]					+						
Family Faviidae											
<i>Cyphastrea chalcidicum</i> (Forskål, 1775)					+						
<i>Diploastrea heliopora</i> (Lamarck, 1816)					+						
<i>Echinopora lamellosa</i> (Esper, 1795)					+						
<i>Echinopora</i> sp.					+						
<i>Favia camranensis</i> Latypov, 2013					+						
<i>Favia fавus</i> (Forskål, 1775)				+	+						
<i>Favia maxima</i> Veron, Pichon et Wijsman-Best, 1977					+						
<i>Favia pallida</i> (Dana, 1846)		+			+						
<i>Favia rotumana</i> (Gardiner, 1899)					+						
<i>Favia speciosa</i> (Dana, 1846)					+						
<i>Favia veroni</i> Moll et Best, 1984					+						
<i>Favia</i> spp.					+		+				
<i>Favites abdita</i> (Ellis et Solander, 1786)					+						
<i>Favites complanata</i> (Ehrenberg, 1834)					+						
<i>Favites valenciennesi</i> (Milne Edwards et Haime, 1849) [= <i>Favia valenciennesi</i>]					+						
<i>Favites virens</i> (Dana, 1846)					+						
<i>Favites</i> spp. [as <i>F. spectabilis</i>]					+		+				
<i>Goniastrea aspera</i> Verrill, 1865 [as <i>G. incrustans</i>]					+						
<i>Goniastrea edwardsi</i> Chevalier, 1971					+						
<i>Goniastrea favulus</i> (Dana, 1846)					+						
<i>Goniastrea pectinata</i> (Ehrenberg, 1834) [= <i>G. quoyi</i>]				+	+						
<i>Goniastrea retiformis</i> (Lamarck, 1816)		+			+						
<i>Goniastrea</i> spp.					+		+				
<i>Leptastrea pruinosa</i> Crossland, 1952					+						
<i>Leptastrea purpurea</i> (Dana, 1846)					+						

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
* <i>Leptoria phrygia</i> (Ellis et Solander, 1786)				+	+						
<i>Oulophyllia aspera</i> Quelch, 1886					+						
* <i>Platygyra daedalea</i> (Ellis et Solander, 1786)				+							
<i>Platygyra lamellina</i> (Ehrenberg, 1834)								+			
<i>Platygyra sinensis</i> (Milne Edwards et Haime, 1849)					+						
[= <i>Meandrina stricta</i>]											
Family Merulinidae											
* <i>Hydnophora exesa</i> (Pallas, 1766)				+	+						
<i>Hydnophora microconos</i> (Lamarck, 1816)					+						
<i>Hydnophora rigida</i> (Dana, 1846) [= <i>Merulina laxa</i>]					+						
<i>Hydnophora</i> sp.								+			
<i>Merulina ampliata</i> (Ellis et Solander, 1786) [= <i>M. vaughani</i>]				+	+						
Family Pectiniidae											
<i>Oxypora lacera</i> (Verrill, 1864)					+						
<i>Pectinia lactuca</i> (Pallas, 1766)					+						
<i>Pectinia paeonia</i> (Dana, 1846)					+						
Family Trachyphylliidae											
<i>Trachyphyllia geoffroyi</i> (Audouin, 1826) [as <i>T. amarantum</i>]					+						
Family Pocilloporidae											
<i>Pocillopora damicornis</i> (Linnaeus, 1758)	+			+	+						
<i>Pocillopora eydouxi</i> Milne Edwards et Haime, 1860					+						
<i>Pocillopora kelleheri</i> Veron, 2000					+						
<i>Pocillopora verrucosa</i> (Ellis et Solander, 1786) [= <i>P. danae</i>]			+	+	+			+			
<i>Pocillopora</i> spp.					+		+				
<i>Seriatopora hystrix</i> Dana, 1846 [= <i>S. angulata</i>]					+						
<i>Seriatopora</i> sp.							+				
<i>Stylophora pistillata</i> (Esper, 1797) [= <i>S. mordax</i>]			+		+						
Family Poritidae											
<i>Goniopora lobata</i> Milne Edwards et Haime, 1851					+						
<i>Goniopora stutchburyi</i> Wells, 1955					+						
<i>Goniopora</i> sp. [as <i>G. malaccensis</i>]					+						
<i>Porites annae</i> Crossland, 1952					+						
<i>Porites australiensis</i> Vaughan, 1918				+	+						
<i>Porites deformis</i> Nemenzo, 1955					+						
<i>Porites lobata</i> Dana, 1846					+	+					
<i>Porites lutea</i> Milne Edwards et Haime, 1860				+	+	+					
<i>Porites nigrescens</i> Dana, 1848				+							
* <i>Porites rus</i> (Forskål, 1775) [= <i>P. convexa</i>]				+	+						
<i>Porites</i> spp. [as <i>P. mucronata</i>]					+		+				
Family Thamnasteriidae											
<i>Psammocora contigua</i> (Esper, 1797)					+						
<i>Psammocora</i> sp.					+						
Family Siderastreidae											
<i>Pseudosiderastrea tayamai</i> Yabe et Sugiyama, 1935					+						
Family Euphyllidae											
<i>Physogyra lichtensteini</i> (Milne Edwards et Haime, 1851)					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Order ZOANTHARIA											
Family Zoanthidae											
<i>Zoanthus cavernarum</i> Pax et Müller, 1957					+						
<i>Zoanthus cyanoides</i> Pax et Müller, 1957					+						
<i>Zoanthus erythrochlora</i> Pax et Müller, 1957					+						
<i>Zoanthus robustus</i> Carlgren, 1950					+						
<i>Zoanthus vietnamensis</i> Pax et Müller, 1957					+						
<i>Zoanthus</i> spp.			+		+	+					
Family Sphenopidae											
<i>Palythoa anthoplax</i> Pax et Müller, 1957					+						
<i>Palythoa stephensoni</i> Carlgren, 1937					+						
<i>Palythoa titanophila</i> Pax et Müller, 1957					+						
<i>Palythoa tuberculosa</i> Klunzinger, 1877								+	+		
Order ANTIPATHARIA											
Family Antipathidae											
<i>Cirripathes</i> cf. <i>anguina</i> (Dana, 1846)					+						
Order ALCYONACEA											
Family Alcyoniidae											
<i>Lobophytum gazellae</i> Moser, 1919 [= <i>L. roxasi</i>]					+						
<i>Sarcophyton cinereum</i> Tixier-Durivault, 1946 [= <i>S. poculiforme</i>]					+						
<i>Sarcophyton crassocaule</i> Moser, 1919 [= <i>Lobophytum carnatum</i> , <i>L. undatum</i>]					+						
<i>Sarcophyton trocheliophorum</i> von Marenzeller, 1886					+						
<i>Sinularia flexibilis</i> (Quoy et Gaimard, 1833)					+						
<i>Sinularia fungoides</i> Thomson et Henderson, 1906					+						
<i>Sinularia gyrosa</i> (Klunzinger, 1877)					+						
<i>Sinularia macropodia</i> (Hickson et Hiles, 1900)					+						
<i>Sinularia pedunculata</i> Tixier-Durivault, 1945					+						
<i>Sinularia polydactyla</i> (Ehrenberg, 1834)					+						
<i>Sinularia querciformis</i> (Pratt, 1903)					+						
<i>Sinularia ramosa</i> Tixier-Durivault, 1945					+						
<i>Sinularia rigida</i> Dana, 1846					+						
<i>Sinularia whiteleggei</i> Lüttschwager, 1914					+						
<i>Sinularia</i> sp.					+						
Family Ellisellidae											
<i>Junceella juncea</i> (Pallas, 1766)					+						
Family Gorgoniidae											
<i>Rumphella aggregata</i> (Nutting, 1910)					+						
Family Nephtheidae											
<i>Dendronephthya gigantea</i> Verrill, 1864 [= <i>Spongodes gigantea</i>]					+						
<i>Litophyton arboreum</i> Forskål, 1775					+						
Family Subergorgiidae											
<i>Subergorgia suberosa</i> (Pallas, 1766)					+						
Order HELIOPORACEA											
Family Helioporidae											
<i>Heliopora coerulea</i> (Pallas, 1766)					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Phylum NEMERTEA											
Class PALAEONEMERTEA											
Order TUBULANIFORMES											
Family Cephalotrichellidae											
<i>Balionemertes</i> sp.					+						
Family Cephalotrichidae											
<i>Cephalothrix suni</i> in lit.	+				+						
Class NEONEMERTEA											
Order HETERONEMERTEA											
Family Lineidae											
* <i>Dushia</i> sp.					+						
<i>Eousia verticivaria</i> Gibson, 1990	+				+						
<i>Lineus binigrilinearis</i> Gibson, 1990					+						
<i>Lineus</i> cf. <i>caputornatus</i> Takakura, 1898	+				+						
<i>Notospermus</i> sp.	+				+						
Order MONOSTILIFERA											
Family Poseidonemertidae											
<i>Diplomma serpentina</i> (Stimpson, 1855)	+				+					+	
Family Oerstediiidae											
<i>Eumonostilifera</i> sp.						+					
Family Tetrastemmatidae											
<i>Tetrastemma</i> ex gr. <i>roseocephalum</i> (Yamaoka, 1947)										+	
Phylum SIPUNCULA											
Class PHASCOLOSOMATIDEA											
Order ASPIDOSIPHONIFORMES											
Family Aspidosiphonidae											
<i>Aspidosiphon</i> (<i>Aspidosiphon</i>) <i>elegans</i> (Chamisso et Eysenhardt, 1821)					+						
<i>Aspidosiphon</i> (<i>Aspidosiphon</i>) <i>muelleri</i> Diesing, 1851					+						
<i>Aspidosiphon</i> (<i>Paraspidosiphon</i>) <i>laevis</i> de Quatrefages, 1865					+						
<i>Aspidosiphon</i> (<i>Paraspidosiphon</i>) <i>parvulus</i> Gerould, 1913					+						
* <i>Aspidosiphon</i> (<i>Paraspidosiphon</i>) <i>steenstrupii</i> Diesing, 1859	+				+						
<i>Aspidosiphon</i> (<i>Paraspidosiphon</i>) <i>tenuis</i> Sluiter, 1886 [= <i>A. (P.) ambonensis</i>]	+				+						
<i>Cloeosiphon aspergillus</i> (de Quatrefages, 1865)					+						
Order PHASCOLOSOMATIFORMES											
Family Phascolosomatidae											
<i>Antillesoma antillarum</i> (Grübe et Oersted, 1858)					+					+	
<i>Apionsoma</i> (<i>Apionsoma</i>) <i>trichocephalus</i> Sluiter, 1902					+					+	
<i>Phascolosoma</i> (<i>Phascolosoma</i>) <i>albolineatum</i> (Baird, 1868)	+				+					+	
<i>Phascolosoma</i> (<i>Phascolosoma</i>) <i>arcuatum</i> (Gray, 1828)		+									
* <i>Phascolosoma</i> (<i>Phascolosoma</i>) <i>nigrescens</i> (Keferstein, 1865) [= <i>Phascolosoma varians</i>]	+		+		+	+	+			+	
* <i>Phascolosoma</i> (<i>Phascolosoma</i>) <i>pacificum</i> Keferstein, 1866					+						
<i>Phascolosoma</i> (<i>Phascolosoma</i>) <i>perlucens</i> Baird, 1868					+						
* <i>Phascolosoma</i> (<i>Phascolosoma</i>) <i>scolops</i> (Selenka et de Man, 1883)	+				+		+			+	
<i>Phascolosoma</i> spp.	+									+	

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Class SIPUNCULIDEA											
Order GOLFINGIIFORMES											
Family Golfingiidae											
<i>Golfingia</i> (<i>Golfingia</i>) <i>elongata</i> (Keferstein, 1862)											+
<i>Thysanocardia catharinae</i> (Grube, 1868)		+			+						+
Family Themistidae											
<i>Themiste</i> (<i>Lagenopsis</i>) <i>lageniformis</i> (Baird, 1868) [= <i>Dendrostomum signifer</i>]					+						
Order SIPUNCULIFORMES											
Family Sipunculidae											
<i>Siphonosoma australe</i> (Keferstein, 1865)					+						+
<i>Siphonosoma cumanense</i> (Keferstein, 1867)					+						
* <i>Sipunculus</i> (<i>Sipunculus</i>) <i>nudus</i> Linnaeus, 1766					+						+
Phylum ANNELIDA											
Class POLYCHAETA											
Order PHYLLODOCIDA											
Family Phyllodocidae											
<i>Nereiphylla castanea</i> (Marenzeller, 1879) [= <i>Genetyllis castanea</i>]					+						+
<i>Phyllodoce tenuissima</i> Grube, 1878					+						
Family Acoetidae											
<i>Acoetes melanonota</i> (Grube, 1876) [= <i>Polyodontes melanonotus</i>]											+
<i>Polyodontes lupinus</i> (Stimpson, 1856) [as <i>P. pleei</i>]											+
<i>Polyodontes tidemani</i> Pflugfelder, 1932											+
Family Aphroditidae											
<i>Laetmonice hystrix</i> (Savigny in Lamarck, 1818) [= <i>Hermione hystrix</i>]					+						
Family Iphionidae											
<i>Iphione muricata</i> (Lamarck, 1818)					+						
Family Polynoidae											
<i>Harmothoe asiatica</i> Uschakov et Wu, 1962				+							
<i>Lepidonotus carinulatus</i> (Grube, 1870)					+						
<i>Lepidonotus tenuisetosus</i> (Gravier, 1902)								+			
<i>Lepidonotus</i> sp.					+						
<i>Paralentia annamita</i> (Fauvel, 1934)				+							
<i>Paralepidonotus ampulliferus</i> (Grube, 1878)					+						
<i>Thormora johnstoni</i> (Kinberg, 1856) [= <i>Lepidonotus johnstoni</i>]					+						
Family Glyceridae											
<i>Glycera alba</i> (O.F. Müller, 1776)					+						
<i>Glycera capitata</i> Örsted, 1843					+						
Family Chrysopetalidae											
<i>Bhawania cryptocephala</i> Gravier, 1901											+
<i>Bhawania goodei</i> Webster, 1884						+					
<i>Chrysopetalum debile</i> (Grube, 1855) [= <i>Ch. ehlersi</i>]				+							
Family Hesionidae											
<i>Leocrates claparedii</i> (Costa in Claparede, 1868)					+						
<i>Parahesion</i> sp.					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Nereididae											
<i>Ceratonereis (Composetia) costae</i> (Grube, 1840) [= <i>Nereis costae</i>]					+						
<i>Ceratonereis mirabilis</i> Kinberg, 1865					+	+					
<i>Hediste diversicolor</i> (O.F. Müller, 1776) [= <i>Nereis viridis</i>]					+						
<i>Leonnates persicus</i> Wesenberg-Lund, 1949										+	
<i>Neanthes pachychaeta</i> (Fauvel, 1918) [= <i>Ceratonereis pachychaeta</i>]					+						
<i>Nereis falcaria</i> (Willey, 1905)					+						
<i>Nereis nicholli</i> Kott, 1951			+					+			
<i>Nereis</i> spp.			+		+						
<i>Perinereis cultrifera</i> (Grube, 1840)					+	+	+	+		+	
<i>Perinereis floridana</i> (Ehlers, 1868) [= <i>P. cultrifera</i> var. <i>floridana</i>]					+						
<i>Perinereis nigropunctata</i> (Horst, 1889)					+						
<i>Perinereis nuntia</i> (Lamarck, 1818) [= <i>Ceratonereis nuntia</i>]					+						
<i>Perinereis nuntia brevicirris</i> (Grube, 1867)					+						
<i>Perinereis vancaurica</i> (Ehlers, 1868)					+						
<i>Perinereis</i> sp.								+			
<i>Platynereis dumerilii</i> (Audouin et Milne Edwards, 1834)					+						
<i>Platynereis pulchella</i> Gravier, 1901					+						
<i>Pseudonereis gallapagensis</i> Kinberg, 1865					+						
<i>Pseudonereis variegata</i> (Grube, 1857)					+						
Nereididae gen. sp.										+	
Family Syllidae											
<i>Autolytus orientalis</i> Willey, 1905			+								
<i>Parasphaerosyllis indica</i> Monro, 1937			+								
<i>Syllis gracilis</i> Grube, 1840			+								
<i>Syllis hyalina</i> Grube, 1863 [= <i>Typosyllis aciculata orientalis</i>]			+				+				
<i>Syllis variegata</i> Grube, 1860 [= <i>Typosyllis variegata</i>]			+								
<i>Syllis</i> sp.					+						
<i>Trypanosyllis zebra</i> (Grube, 1860)					+						
<i>Typosyllis maculata</i> Imajima, 1966				+							
Syllidae gen. sp.					+						
Order AMPHINOMIDA											
Family Amphinomidae											
<i>Eurythoe complanata</i> (Pallas, 1766)					+	+					
<i>Linopherus paucibranchiata</i> (Fauvel, 1932) [= <i>Pseudeurythoe paucibranchiata</i>]					+						
Amphinomidae gen. sp.										+	
Order EUNICIDA											
Family Eunicidae											
<i>Eunice afra</i> Peters, 1854					+						
<i>Eunice aphroditois</i> (Pallas, 1788)					+						
<i>Eunice coccinea</i> Grube, 1878					+						
<i>Eunice gracilis</i> Grube, 1866					+						
<i>Eunice grubei</i> Gravier, 1900					+						
<i>Eunice kubiensis</i> McIntosh, 1885			+								

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Eunice tubifex</i> Crossland, 1904					+						
<i>Eunice</i> sp.					+						
<i>Leodice antennata</i> Savigny in Lamarck, 1818 [= <i>Eunice antennata</i>]			+	+	+	+					
<i>Lysidice collaris</i> Grube, 1870			+		+			+			
<i>Lysidice unicornis</i> (Grube, 1840) [= <i>Nematonereis unicornis</i>]					+	+				+	
<i>Marphysa mossambica</i> (Peters, 1854)					+						
<i>Marphysa sanguinea</i> (Montagu, 1815)							+				
<i>Nicidion cincta</i> Kinberg, 1865 [= <i>Eunice cincta</i>]					+						
<i>Palola siciliensis</i> (Grube, 1840) [= <i>Palolo siciliensis</i> , <i>Eunice siciliensis</i>]			+		+	+		+			
Family Onuphidae											
<i>Diopatra neapolitana</i> Delle Chiaje, 1841					+					+	
<i>Onuphis eremita</i> Audouin et Milne Edwards, 1833										+	
Family Lumbrineridae											
<i>Lumbrineris heteropoda</i> (Marenzeller, 1879)					+						
<i>Lumbrineris shiinoi</i> Gallardo, 1968										+	
Family Oeononidae											
<i>Arabella mutans</i> (Chamberlin, 1919) [= <i>A. novecrinita</i>]										+	
Family Dorvilleidae											
<i>Dorvillea</i> sp.			+								
Order TERESELLIDA											
Family Terebellidae											
<i>Lanice conchilega</i> (Pallas, 1766)										+	
<i>Loimia medusa</i> (Savigny in Lamarck, 1818)					+	+					
<i>Nicolea venustula</i> (Montagu, 1818)					+						
<i>Pista cristata</i> (O.F. Müller, 1776)					+						
<i>Terebella ebrenbergi</i> Gravier, 1906										+	
<i>Thelepus plagiostoma</i> (Schmarda, 1861)					+						
Family Cirratulidae											
<i>Aphelocheata multifilis</i> (Moore, 1909) [= <i>Tharyx multifilis</i>]										+	
<i>Cirratulus cirratus</i> (O.F. Müller, 1776)						+					
<i>Cirratulus</i> sp.					+						
<i>Cirriformia semicincta</i> (Ehlers, 1905)			+	+							
<i>Dodecaceria fistulicola</i> Ehlers, 1901					+						
<i>Tharyx</i> sp.										+	
Family Trichobranchidae											
<i>Terebellides stroemii</i> Sars, 1835				+	+						
Order SABELLIDA											
Family Sabellidae											
Sabellidae gen. sp.										+	
Family Sabellariidae											
<i>Idanthyrus pennatus</i> (Peters, 1854) [= <i>Pallasia pennata</i>]					+						
Family Serpulidae											
<i>Neodexiospira foraminosa</i> (Bush in Moore et Bush, 1904) [= <i>Spirorbis foraminosus</i>]					+						
<i>Pomatoceros caeruleus</i> (Schmarda, 1861)					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Salmacina incrustans</i> Claparède, 1870					+						
<i>Serpula vermicularis</i> Linnaeus, 1767					+						
<i>Spirobranchus giganteus</i> (Pallas, 1766)					+		+	+			
<i>Spirobranchus kraussii</i> (Baird, 1865) [= <i>Pomatoleios kraussii</i>]					+						
<i>Spirorbis</i> (<i>Spirorbis</i>) <i>spirorbis</i> (Linnaeus, 1758) [= <i>S. borealis</i>]					+						
Serpulidae gen. sp.			+								
Order ECHIUROIDEA											
Family Echiuridae											
<i>Ochetostoma erythrogrammon</i> Leuckart et Rüppell, 1828					+						
Echiuridae gen. sp.										+	
Order uncertain											
Family Chaetopteridae											
<i>Chaetopterus variopedatus</i> (Renier, 1804)										+	
<i>Chaetopterus</i> sp.										+	
Family Orbiniidae											
<i>Scoloplos</i> (<i>Leodamas</i>) <i>uniramus</i> Day, 1961					+						
<i>Scoloplos</i> sp.					+						
Orbiniidae gen. sp.										+	
Family Capitellidae											
<i>Dasybranchus caducus</i> (Grube, 1846)					+						
<i>Heteromastus similis</i> Southern, 1921										+	
Family Maldanidae											
<i>Axiothella</i> sp.										+	
Family Opheliidae											
<i>Armandia lanceolata</i> Willey, 1905					+						
<i>Ophelina</i> sp. [= <i>Ammotrypane</i> sp.]										+	
<i>Polyophthalmus pictus</i> (Dujardin, 1839)					+						
Phylum ARTHROPODA											
Class MEROSTOMATA											
Order XIPHOSURIDA											
Family Limulidae											
<i>Tachypleus tridentatus</i> (Leach, 1819)										+	
<i>Tachypleus</i> sp.										+	
Class MAXILLOPODA											
Order IBLIFORMES											
Family Iblidae											
<i>Ibla cumingi</i> Darwin, 1851					+		+			+	
<i>Ibla</i> sp.										+	
Order LEPADIFORMES											
Family Poecilasmatidae											
<i>Octolasmis angulata</i> (Aurivillius, 1894)										+	
<i>Octolasmis cor</i> (Aurivillius, 1892)										+	
Order SCALPELLIFORMES											
Family Scalpellidae											
<i>Scalpellum typicum</i> Broch, 1947								+			
Family Lithotryidae											
<i>Lithotrya nicobarica</i> Reinhardt, 1850		+								+	

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Pollicipedidae											
<i>Capitulum mitella</i> (Linnaeus, 1758) [= <i>Mitella mitella</i> , <i>Pollicipes mitella</i>]	+	+			+					+	
<i>Pollicipes pollicipes</i> (Gmelin, 1790) [= <i>Mitella pollicipes</i>]					+			+			
<i>Pollicipes</i> sp.								+			
Order SESSILIA											
Family Archaeobalanidae											
<i>Acasta sulcata</i> Lamarck, 1818	+				+		+	+		+	
<i>Euacasta doylei</i> (Kruger, 1911)											+
<i>Euacasta sporillus</i> (Darwin, 1854) [= <i>Acasta sporillus</i>]										+	
* <i>Solidobalanus socialis</i> (Hoek, 1883)					+					+	
Family Balanidae											
<i>Amphibalanus amphitrite</i> (Darwin, 1854) [= <i>Balanus amphitrite</i>]					+					+	
<i>Amphibalanus reticulatus</i> (Utinomi, 1967) [= <i>Balanus reticulatus</i>]				+						+	
<i>Balanus</i> spp.		+	+		+					+	
<i>Megabalanus occator</i> (Darwin, 1854)		+									
<i>Megabalanus tintinnabulum</i> (Linnaeus, 1758) [= <i>Balanus tintinnabulum</i>]	+		+		+						
<i>Megabalanus</i> sp.			+								
Family Chthamalidae											
<i>Caudoeuraphia caudata</i> (Pilsbry, 1916) [= <i>Chthamalus caudatus</i>]					+						
<i>Chinochthamalus scutelliformis</i> (Darwin, 1854) [= <i>Chamaesipho scutelliformis</i>]	+				+		+	+		+	
<i>Chthamalus challengeri</i> Hoek, 1883					+					+	
<i>Chthamalus malayensis</i> Pilsbry, 1916	+		+	+	+		+	+		+	
<i>Chthamalus moro</i> Pilsbry, 1916	+										
<i>Chthamalus stellatus</i> (Poli, 1791)		+									
<i>Chthamalus</i> spp.					+					+	
<i>Microeuraphia withersi</i> (Pilsbry, 1916) [= <i>Chthamalus withersi</i>]	+				+		+	+		+	
<i>Tetrachthamalus sinensis</i> Ren, 1980					+			+		+	
Family Pyrgomatidae											
* <i>Cantellius iwayama</i> (Hiro, 1983)					+		+				
Family Tetracitidae											
<i>Tesseropora alba</i> Ren et Liu, 1979					+					+	
* <i>Tetracitella japonica</i> Pilsbry, 1916	+	+	+	+	+	+	+	+	+	+	
<i>Tetracitella porosa</i> Darwin, 1854			+		+						
* <i>Tetracitella squamosa</i> (Bruguère, 1789)	+	+	+	+	+	+	+	+	+	+	
<i>Tetracitella</i> spp.	+			+	+						
<i>Tetracitella costata</i> (Darwin, 1854)					+		+				
* <i>Tetracitella divisa</i> (Nilsson-Cantell, 1921)											
<i>Yamaguchiella coerulescens</i> (Spengler, 1790) [= <i>Tetracitella coerulescens</i>]	+										

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Class MALACOSTRACA											
Order STOMATOPODA											
Family Gonodactylidae											
<i>Gonodactylaceus glabrous</i> (Brooks, 1886) [= <i>Gonodactylus glaber</i>]					+						
<i>Gonodactylellus viridis</i> (Serène, 1954)					+						
<i>Gonodactylus chiragra</i> (Fabricius, 1781)					+	+				+	
<i>Gonodactylus smithii</i> Pocock, 1893					+						
<i>Gonodactylus</i> sp. [as <i>G. brooksi</i>]					+						
Family Protosquillidae											
<i>Chorisquilla excavata</i> (Miers, 1880) [= <i>Gonodactylus excavatus</i>]					+						
<i>Haptosquilla glyptocercus</i> (Wood-Mason, 1875) [= <i>Gonodactylus glyptocercus</i>]					+						
* <i>Haptosquilla stoliura</i> (Müller, 1887)					+					+	
Family Pseudosquillidae											
<i>Pseudosquilla ciliata</i> (Fabricius, 1787)					+						
Family Squillidae											
<i>Alima neptuni</i> (Linnaeus, 1768)					+						
<i>Cloridina pelamidae</i> (Blumstein, 1970)										+	
<i>Cloridopsis scorpio</i> (Latreille, 1828) [= <i>Squilla scorpio</i>]										+	
<i>Oratosquillina gravieri</i> (Manning, 1978)										+	
<i>Oratosquillina interrupta</i> (Kemp, 1911)										+	
Family Takuidae											
* <i>Taku spinosocarinatus</i> (Fukuda, 1909)					+						
Order AMPHIPODA											
Family Photidae											
Photidae gen. sp.									+		
Family Isaeidae											
Isaeidae gen. sp.					+						
Family Pontogeneiidae											
<i>Pontogeneia</i> sp.					+						
Family Hyalidae											
<i>Allorchestes</i> sp.					+						
<i>Hyale</i> spp.					+	+			+		
Family Ampithoidae											
<i>Ampithoe</i> spp.					+	+			+	+	
Family Gammaridae											
<i>Maera</i> spp.					+				+		
<i>Elasmopus</i> sp.					+						
Family Amphilochidae											
<i>Gitanopsis</i> sp.					+						
Family Haustoriidae											
Haustoriidae gen. sp.					+						
Family Ampeliscidae											
<i>Ampelisca</i> sp.					+						
Family Ischyroceridae											
<i>Erichthonius</i> sp.					+						
<i>Ischyrocerus</i> sp.											

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Caprellidae											
<i>Caprella</i> sp.				+							
Order ISOPODA											
Family Cirolanidae											
<i>Aphantolana sphaeromiformis</i> (Hansen, 1890) [= <i>Metacirolana sphaeromiformis</i>]				+	+						
<i>Cirolana erodiae</i> Bruce, 1986											+
<i>Cirolana</i> sp.			+								
<i>Excirolana orientalis</i> (Dana, 1853)					+						
<i>Metacirolana</i> sp.											+
Family Corallanidae											
<i>Corallana hirsuta</i> Schioedte et Meinert, 1879					+						
<i>Lanocira anasicula</i> Jones, 1982					+			+			
<i>Lanocira gardineri</i> Stebbing, 1904								+			
<i>Lanocira</i> sp.					+						
Family Leptanthuridae											
<i>Leptanthura orientalis</i> Barnard, 1925			+								
Family Expanathuridae											
<i>Panathura</i> spp.			+					+			
Family Gnathiidae											
<i>Elaphognathia rangifer</i> Monod, 1926					+						
<i>Gnathia</i> spp.					+					+	
Family Sphaeromatidae											
<i>Cerceis pravipalma</i> Harrison et Holdich, 1982				+	+	+		+			
<i>Chitonosphaera lata</i> (Nishimura, 1968)											+
<i>Cymodoce longistylis</i> Miers, 1884					+						
<i>Cymodoce pelsarti</i> Tattersall, 1922					+						+
<i>Cymodoce tribullis</i> Harrison et Holdich, 1984				+							
<i>Dynamenella liochroea</i> Harrison et Holdich, 1982					+						
<i>Dynamenella trachydermata</i> Harrison et Holdich, 1982			+		+	+	+	+			
<i>Dynamenopsis</i> sp.					+						
<i>Dynoides amblysinus</i> (Pillai, 1954) [= <i>Clanella brucei</i>]			+								
<i>Dynoides harrisoni</i> Kussakin et Malyutina, 1993											+
<i>Paracerceis holdichi</i> Kussakin et Malyutina, 1993					+						
<i>Paracilicæa asiatica</i> Kussakin, Malyutina et Rostomov, 1990			+								
<i>Paradella octaphymata</i> Harrison et Holdich, 1982					+						
<i>Paraleptosphaeroma brucei</i> Kussakin et Malyutina, 1993											+
<i>Sphaeroma terebrans</i> Bate, 1866					+						
<i>Zuzara digitata</i> Harrison et Holdich, 1984				+							
<i>Zuzara curtispina</i> Harrison et Holdich, 1984				+							
Sphaeromatidae gen. sp.			+								
Family Limnoriidae											
<i>Limnoria indica</i> Becker et Kampf, 1958								+			
<i>Limnoria multipunctata</i> Menzies, 1957				+							+
<i>Limnoria tuberculata</i> Sowinsky, 1884											+
<i>Limnoria</i> sp.				+							
<i>Paralimnoria andrewsi</i> (Calman, 1910)								+			

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Anthuridae											
<i>Amakusanthura</i> sp.				+							
Family Joeropsididae											
<i>Joeropsis</i> spp.				+				+			
Family Janiridae											
<i>Caecijaera kussakini</i> Malyutina, 1994				+						+	
Family Ligiidae											
<i>Ligia exotica</i> Roux, 1828					+						
<i>Ligia oceanica</i> (Linnaeus, 1767)					+						
<i>Ligia</i> spp.		+				+		+		+	
Order DECAPODA											
Family Penaeidae											
<i>Penaeus latisulcatus</i> Kishinouye, 1896 [= <i>Melicertus latisulcatus</i>]					+						
Penaeidae gen. sp.										+	
Family Stenopodidae											
<i>Stenopus hispidus</i> (Olivier, 1811)					+						
Family Palaemonidae											
<i>Cuapetes grandis</i> (Stimpson, 1860) [= <i>Kemponia grandis</i>]					+						
<i>Neoanchistus cardiodytes</i> Bruce, 1975					+						
<i>Palaemonella aliska</i> Marin, 2008 [= <i>Palaemonella</i> sp.]					+						
<i>Philarius condi</i> Marin, 2012					+						
Family Alpheidae											
<i>Alpheus bisincisus</i> de Haan, 1849					+						
<i>Alpheus deuteropus</i> Hilgendorf, 1879					+						
<i>Alpheus edwardsii</i> (Audouin, 1826) [= <i>A. audouini</i>]					+						
<i>Alpheus gracilipes</i> Stimpson, 1860					+						
<i>Alpheus lobidens</i> de Haan, 1849 [= <i>A. crassimanus</i>]					+						
<i>Alpheus lottini</i> Guérin-Méneville, 1838					+						
<i>Alpheus obesomanus</i> Dana, 1852 [= <i>A. lutini</i>]					+						
<i>Alpheus pacificus</i> Dana, 1852					+						
<i>Alpheus pubescens</i> de Man, 1908					+						
<i>Alpheus serenei</i> Tiwari, 1964					+						
<i>Alpheus strenuus strenuus</i> Dana, 1852 [= <i>A. strenuus</i>]					+						
<i>Alpheus</i> spp.					+	+					
<i>Synalpheus pescadorensis</i> Coutière, 1905					+						
Alpheidae gen. sp.										+	
Family Callianassidae											
<i>Callianassa</i> sp.										+	
Family Thalassinidae											
<i>Thalassina anomala</i> Herbst, 1804 [= <i>Th. scorpionides</i>]					+					+	
Thalassinidae gen. sp.										+	
Family Palinuridae											
<i>Panulirus</i> sp.					+						
Family Galatheididae											
<i>Allogalathea elegans</i> (Adams et White, 1848) [= <i>Galathea elegans</i>]					+						
<i>Galathea platycheles</i> Miyake, 1953					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Munididae											
<i>Munida</i> sp.					+						
Family Porcellanidae											
<i>Pachycheles stevensii</i> Stimpson, 1858					+						
<i>Petrolisthes asiaticus</i> (Leach, 1820)					+						
<i>Petrolisthes boscii</i> (Audouin, 1826)					+						
<i>Petrolisthes tomentosus</i> (Dana, 1852) [= <i>P. penicillatus</i>]					+						
<i>Petrolisthes</i> spp.					+					+	
<i>Polyonyx</i> sp.										+	
<i>Porcellana</i> sp.					+						
Family Coenobitidae											
<i>Coenobita cavipes</i> Stimpson, 1858					+						
<i>Coenobita rugosus</i> H. Milne Edwards, 1837					+						
<i>Coenobita</i> spp.					+		+			+	
Family Diogenidae											
<i>Calcinus gaimardii</i> (H. Milne Edwards, 1848)					+						
<i>Calcinus laevimanus</i> (Randall, 1840) [= <i>C. herbsti</i>]					+						
<i>Calcinus latens</i> (Randall, 1840) [as <i>C. lateus</i>]					+						
<i>Calcinus</i> spp.							+		+		
<i>Clibanarius arethusa</i> de Man, 1888					+						
<i>Clibanarius corallinus</i> (H. Milne Edwards, 1848)					+						
<i>Clibanarius cruentatus</i> (H. Milne Edwards, 1848)					+						
<i>Clibanarius eurysternus</i> (Hilgendorf, 1879)					+						
<i>Clibanarius lineatus</i> (H. Milne Edwards, 1848)					+						
<i>Clibanarius longitarsus</i> (de Haan, 1849)					+						
<i>Clibanarius merguensis</i> de Man, 1888					+						
<i>Clibanarius ransoni</i> Forest, 1953					+						
<i>Clibanarius snelli</i> Buitendijk, 1937					+						
<i>Clibanarius striolatus</i> Dana, 1852					+						
<i>Clibanarius virescens</i> (Krauss, 1843)					+						
<i>Clibanarius</i> sp.					+						
<i>Dardanus deformis</i> (H. Milne Edwards, 1836)					+						
[= <i>Pagurus deformis</i> , as <i>Calcinus deformis</i>]											
<i>Dardanus guttatus</i> (Olivier, 1812) [= <i>Pagurus guttatus</i>]					+						
<i>Dardanus lagopodes</i> (Forskål, 1775) [= <i>Pagurus sanguinolentus</i>]					+						
<i>Dardanus megistos</i> (Herbst, 1804)					+						
[= <i>Pagurus megistos</i> , <i>P. punctulatus</i>]											
Family Paguridae											
<i>Pagurus</i> sp. [as <i>P. impatiens</i>]					+						
Paguridae gen. spp.					+	+	+	+		+	
Family Raninidae											
<i>Ranina ranina</i> (Linnaeus, 1758)					+						
Family Calappidae											
<i>Calappa hepatica</i> (Linnaeus, 1758)					+	+					
<i>Calappa philargius</i> (Linnaeus, 1758)					+						
<i>Cycloes granulosa</i> de Haan, 1837					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Matutidae											
<i>Ashtoret lunaris</i> (Forskål, 1775) [= <i>Matuta lunaris</i>]					+					+	
<i>Matuta victor</i> (Fabricius, 1781)					+						
Family Carpiliidae											
<i>Carpilius convexus</i> (Forskål, 1775)					+					+	
<i>Carpilius corallinus</i> (Herbst, 1783)					+						
Family Dacryopilumnidae											
<i>Dacryopilumnus rathbunae</i> Balss, 1932					+						
Family Dairidae											
<i>Daira perlata</i> (Herbst, 1790)					+						
Family Dorippidae											
<i>Dorippoides facchino</i> (Herbst, 1785) [= <i>Dorippe astuta</i>]										+	
Family Eriphiidae											
<i>Eriphia scabricula</i> Dana, 1852				+			+				
<i>Eriphia smithii</i> MacLeay, 1838 [as <i>E. laevimana smithii</i>]					+					+	
Family Menippidae											
<i>Myomenippe hardwickii</i> (Gray, 1831) [as <i>M. granulosa</i>]										+	
<i>Sphaerozius scaber</i> (Fabricius, 1798)			+								
Family Oziidae											
<i>Epixanthus corrosus</i> A. Milne-Edwards, 1873					+						
<i>Epixanthus frontalis</i> (H. Milne Edwards, 1834)					+					+	
<i>Epixanthus</i> sp.					+						
<i>Eupilumnus actumnoides</i> (A. Milne Edwards, 1873)				+		+					
[= <i>Globopilumnus actumnoides</i>]											
<i>Eupilumnus globosus</i> (Dana, 1852) [= <i>Globopilumnus globosus</i>]					+						
<i>Lydia annulipes</i> (H. Milne Edwards, 1834)					+						
[= <i>Euxanthus rugulosus</i>]					+						
<i>Ozius lobatus</i> Heller, 1865					+						
<i>Ozius rugulosus</i> Stimpson, 1858					+						
<i>Ozius tuberculosus</i> H. Milne Edwards, 1834					+						
Family Goneplacidae											
Goneplacidae gen. sp.				+							
Family Leucosiidae											
<i>Ebalia</i> sp.										+	
<i>Nucia tuberculosa</i> A. Milne-Edwards, 1874					+						
<i>Oreophorus</i> (<i>Oreophorus</i>) <i>patella</i> (Alcock, 1896)					+						
<i>Philyra olivacea</i> Rathbun, 1909										+	
<i>Philyra</i> sp.										+	
Family Epialtidae											
<i>Criocarcinus superciliosus</i> (Linnaeus, 1767)					+						
<i>Menaethius monoceros</i> (Latreille, 1825)					+	+					
<i>Pisa lanata</i> (Lamarck, 1801) [as <i>P. lamaia</i>]					+						
Family Hymenosomatidae											
<i>Halicarcinus messor</i> (Stimpson, 1858) [= <i>Rhynchoplax messor</i>]					+						
<i>Halicarcinus orientalis</i> Sakai, 1932					+					+	
Family Inachidae											
<i>Oncinopus araneus</i> (de Haan, 1839)					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Majidae											
<i>Schizophrys aspera</i> (H. Milne Edwards, 1834)					+						
Family Orithyiidae											
<i>Orithyia sinica</i> (Linnaeus, 1771) [=as <i>O. mammillaris</i>]										+	
Family Pilumnidae											
<i>Actumnus setifer</i> (de Haan, 1835)					+						
<i>Benthopanope eucratoides</i> (Stimpson, 1858) [= <i>Heteropanope (Pilumnopeus) eucratoides</i>]					+					+	
<i>Benthopanope pearsei</i> (Rathbun, 1932) [= <i>Heteropanope pearsei</i> , as <i>Parapilumnus pearsi</i>]					+						
<i>Eurycarcinus orientalis</i> A. Milne-Edwards, 1867										+	
<i>Eurycarcinus</i> sp.										+	
<i>Glabropilumnus dispar</i> (Dana, 1852)					+						
<i>Glabropilumnus laevimanus</i> (Dana, 1852) [= <i>Pilumnus laevimanus</i>]					+						
<i>Heteropanope glabra</i> Stimpson, 1858			+		+		+			+	
<i>Nanopilumnus barbatus</i> (A. Milne-Edwards, 1873) [= <i>Pilumnus barbatus</i>]					+						
<i>Pilumnopeus makianus</i> (Rathbun, 1931) [= <i>Heteropanope makianus</i>]					+						
<i>Pilumnus rufopunctatus</i> Stimpson, 1858					+						
<i>Pilumnus scabriusculus</i> Adams et White, 1849					+						
<i>Pilumnus tomentosus</i> Latreille, 1825					+						
<i>Pilumnus trispinosus</i> (Sakai, 1965) [= <i>Parapilumnus trispinosus</i>]					+						
<i>Pilumnus vespertilio</i> (Fabricius, 1793)					+	+					
<i>Pilumnus</i> spp.			+					+	+		
<i>Rhizopa gracilipes</i> Stimpson, 1858										+	
<i>Ser fukiensis</i> Rathbun, 1931										+	
<i>Typhlocarcinus</i> sp.										+	
Family Portunidae											
<i>Carupella banlaensis</i> Tien, 1969										+	
<i>Charybdis (Charybdis) anisodon</i> (de Haan, 1850)										+	
<i>Charybdis (Charybdis) annulata</i> (Fabricius, 1798)										+	
<i>Charybdis (Charybdis) hellerii</i> (A. Milne-Edwards, 1867)										+	
<i>Podophthalmus vigil</i> (Fabricius, 1798)										+	
<i>Portunus sanguinolentus</i> (Herbst, 1783)					+						
<i>Portunus (Portunus) pelagicus</i> (Linnaeus, 1758)					+					+	
<i>Portunus (Portunus) trituberculatus</i> (Miers, 1876)										+	
<i>Scylla paramamosain</i> Estampador, 1949			+		+						
<i>Scylla serrata</i> (Forskål, 1775) [= <i>S. tranquebarica</i> var. <i>oceanica</i> , <i>S. oceanica</i>]					+					+	
<i>Thalamita admete</i> (Herbst, 1803)						+					
<i>Thalamita crenata</i> Rüppell, 1830					+					+	
<i>Thalamita danae</i> Stimpson, 1858					+					+	
<i>Thalamita kotoensis</i> Tien, 1969										+	
<i>Thalamita prymna</i> (Herbst, 1803)					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Thalamita sima</i> H. Milne Edwards, 1834					+					+	
<i>Thalamita</i> spp.					+					+	
Family Domeciidae											
<i>Domecia hispida</i> Eydoux et Souleyet, 1842								+			
Family Tetraliidae											
<i>Tetralia glaberrima</i> (Herbst, 1790)			+		+			+			
<i>Tetralia heterodactyla</i> Heller, 1861					+						
<i>Tetralia nigrolineata</i> Serène et Pham, 1957 [as <i>T. glaberrima</i> var. <i>nigrolineata</i>]					+						
Family Trapeziidae											
<i>Trapezia areolata</i> Dana, 1852					+			+			
<i>Trapezia cymodoce</i> (Herbst, 1801)					+						
<i>Trapezia guttata</i> Rüppell, 1830 [as <i>T. cymodoce guttata</i>]					+						
<i>Trapezia rufopunctata</i> (Herbst, 1799)					+						
<i>Trapezia speciosa</i> Dana, 1852					+						
Family Xanthidae											
<i>Actaea amoyensis</i> (de Man, 1879)					+						
<i>Actaea polyacantha</i> (Heller, 1861)					+						
<i>Actaea rueppellii</i> (Krauss, 1843)					+						
<i>Actaea</i> spp.			+		+						
<i>Actaeodes tomentosus</i> (H. Milne Edwards, 1834) [= <i>Actaea tomentosa</i>]					+			+	+		
<i>Atergatis floridus</i> (Linnaeus, 1767)					+						
<i>Atergatis integerrimus</i> (Lamarck, 1818)					+						
<i>Chlorodiella cytherea</i> (Dana, 1852)					+						
<i>Chlorodiella laevissima</i> (Dana, 1852)					+						
<i>Chlorodiella nigra</i> (Forskål, 1775)					+						
<i>Chlorodiella</i> sp.								+			
<i>Chlorodopsis pilumnoides</i> (White, 1848)					+						
<i>Cyclodius granulatus</i> (Targioni-Tozzetti, 1877) [as <i>Chlorodopsis granulata</i>]					+						
<i>Epiactaea margaritifera</i> (Odhner, 1925) [= <i>Actaea margaritifera</i>]					+						
<i>Etisus laevimanus</i> Randall, 1840					+						
<i>Forestiana scabra</i> (Odhner, 1925) [= <i>Actaea scabra</i>]					+						
<i>Lachnopus subacutus</i> (Stimpson, 1858) [= <i>Lioxantho tumidus</i>]					+		+				
<i>Leptodius exaratus</i> (H. Milne Edwards, 1834) [= <i>Xantho</i> (<i>Leptodius</i>) <i>exaratus</i>]					+	+		+	+	+	
<i>Liomera caelata</i> (Odhner, 1925)					+						
<i>Liomera laevis</i> (A. Milne-Edwards, 1873)					+						
<i>Liomera monticulosa</i> (A. Milne-Edwards, 1873)					+						
<i>Liomera rugipes</i> (Heller, 1861)					+						
<i>Liomera semigranosa</i> de Man, 1888					+						
<i>Macromedaeus nudipes</i> (A. Milne-Edwards, 1867) [= <i>Xantho</i> (<i>Leptodius</i>) <i>nudipes</i>]					+						
<i>Macromedaeus quinquedentatus</i> (Krauss, 1843) [= <i>Xantho</i> (<i>Leptodius</i>) <i>euglyptus</i>]					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Novactaea modesta</i> (de Man, 1888) [= <i>Actaeodes modesta</i>]					+						
<i>Paractaea rufopunctata</i> (H. Milne Edwards, 1834) [= <i>Actaea rufopunctata</i>]					+						
<i>Phymodius monticulosus</i> (Dana, 1852)					+						
<i>Phymodius</i> sp.						+					
<i>Pilodius nigrocrinitus</i> Stimpson, 1859 [= <i>Chlorodopsis melanochira</i>]					+						
<i>Pilodius pugil</i> Dana, 1852 [as <i>Chlorodopsis pugil</i>]					+						
<i>Pilodius</i> sp.							+				
<i>Platypodia alcocki</i> Buitendijk, 1941					+						
<i>Psaumis cavipes</i> (Dana, 1852) [= <i>Actaea cavipes</i>]					+						
<i>Pseudoliomera helleri</i> (A. Milne-Edwards, 1865) [= <i>Actaea helleri</i>]					+						
<i>Pseudoliomera speciosa</i> (Dana, 1852) [= <i>Actaea speciosa</i>]					+						
<i>Pseudoliomera variolosa</i> (Borradaile, 1902) [= <i>Actaea variolosa</i>]					+						
<i>Xanthias lamarckii</i> (H. Milne Edwards, 1834)					+						
<i>Xanthias punctatus</i> (H. Milne Edwards, 1834)					+						
<i>Xanthodius</i> sp.					+						
<i>Zosimus aeneus</i> (Linnaeus, 1758) [= <i>Zozymus aeneus</i>]					+						
<i>Zozymodes cavipes</i> (Dana, 1852)					+			+			
<i>Zozymodes pumilus</i> (Hombron et Jacquinot, 1846) [= <i>Zozymus pumilus</i>]					+						
Xanthidae gen. sp.				+							
Family Grapsidae											
<i>Grapsus grapsus</i> (Linnaeus, 1758)					+						
<i>Grapsus longitarsis</i> Dana, 1851 [= <i>G. subquadratus</i>]					+						
<i>Grapsus tenuicrustatus</i> (Herbst, 1783)			+		+		+	+	+	+	
<i>Metopograpsus latifrons</i> (White, 1847)		+			+					+	
<i>Metopograpsus messor</i> (Forskål, 1775)					+	+	+				
<i>Metopograpsus oceanicus</i> (Hombron et Jacquinot, 1846)					+						
<i>Metopograpsus quadridentatus</i> Stimpson, 1858										+	
<i>Metopograpsus thukuhar</i> (Owen, 1839)										+	
<i>Metopograpsus</i> sp. [as <i>M. dentatus</i>]										+	
<i>Pachygrapsus minutus</i> A. Milne Edwards, 1873			+		+		+	+			
<i>Pachygrapsus planifrons</i> de Man, 1888					+						
Grapsidae gen. spp.		+								+	
Family Percnidae											
<i>Percnon planissimum</i> (Herbst, 1804)					+						
<i>Percnon</i> spp.			+				+				
Family Plagusiidae											
<i>Plagusia immaculata</i> Lamarck, 1818					+						
<i>Plagusia squamosa</i> (Herbst, 1790) [= <i>P. tuberculata</i>]					+						
Family Sesarmidae											
<i>Clistocoeloma merguense</i> de Man, 1888										+	
<i>Episesarma mederi</i> (H. Milne Edwards, 1853) [= <i>Sesarma taeniolata</i>]										+	

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Episesarma palawanense</i> (Rathbun, 1914)		+			+						
<i>Nanosesarma batavicum</i> (Moreira, 1903)		+									
<i>Nanosesarma edamense</i> (de Man, 1887)					+						
<i>Nanosesarma minutum</i> (de Man, 1887) [= <i>N. gordonii</i>]		+			+					+	
<i>Nanosesarma tweediei</i> (Serène, 1967)					+						
<i>Neosarmatium smithi</i> (H. Milne Edwards, 1853) [= <i>Sesarma smithi</i>]										+	
<i>Parasesarma batavianum</i> (de Man, 1890) [= <i>Sesarma bataviana</i>]										+	
<i>Parasesarma moluccense</i> (de Man, 1892) [as <i>Sesarma molluccensis</i>]										+	
<i>Parasesarma pictum</i> (de Haan, 1835) [as <i>Sesarma picta</i>]										+	
<i>Parasesarma plicatum</i> (Latreille, 1803) [= <i>Sesarma plicata</i>]		+								+	
<i>Parasesarma unguatum</i> (H. Milne Edwards, 1853)					+						
<i>Perisesarma bidens</i> (de Haan, 1835) [= <i>Sesarma bidens</i>]					+					+	
<i>Perisesarma eumolpe</i> (de Man, 1895) [= <i>Sesarma eumolpe</i>]					+					+	
<i>Perisesarma indiarum</i> (Tweedie, 1940) [as <i>Sesarma bidens indiarum</i>]					+						
<i>Sarmatium crassum</i> Dana, 1851										+	
<i>Sesarma dehaani</i> H. Milne Edwards, 1853										+	
<i>Sesarma obtusifrons</i> Dana, 1851					+						
<i>Sesarma</i> spp.								+	+		+
Family Varunidae											
<i>Cyclograpsus intermedius</i> Ortmann, 1894					+						
<i>Gaetice depressus</i> (de Haan, 1833)										+	
<i>Helicana wuana</i> (Rathbun, 1931) [= <i>Helice wuana</i>]										+	
<i>Helice tridens</i> (de Haan, 1835)										+	
<i>Helice</i> sp.										+	
<i>Hemigrapsus sanguineus</i> (de Haan, 1835)										+	
<i>Metaplax elegans</i> de Man, 1888										+	
<i>Metaplax longipes</i> Stimpson, 1858					+					+	
<i>Metaplax sheni</i> Gordon, 1930										+	
<i>Metaplax</i> sp.										+	
<i>Varuna litterata</i> (Fabricius, 1798)										+	
Family Camptandriidae											
<i>Baruna socialis</i> Stebbing, 1904 [= <i>Leipocten sordidulum</i>]					+						
<i>Camptandrium sexdentatum</i> Stimpson, 1858										+	
<i>Deiratonotus cristatum</i> (de Man, 1895) [= <i>Paracleistostoma cristatum</i>]										+	
<i>Ilyogynnis microcheirum</i> (Tweedie, 1937) [= <i>Paracleistostoma microcheirum</i>]										+	
<i>Mortensenella forceps</i> Rathbun, 1909										+	
<i>Paracleistostoma depressum</i> de Man, 1895										+	
Family Dotillidae											
<i>Dotilla wichmanni</i> de Man, 1892										+	
<i>Ilyoplax</i> cf. <i>formosensis</i> Rathbun, 1921					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Ilyoplax orientalis</i> (de Man, 1888)										+	
<i>Ilyoplax pingi</i> Shen, 1932										+	
<i>Ilyoplax punctata</i> Tweedie, 1935			+								
<i>Ilyoplax pusilla</i> (de Haan, 1835)					+						
<i>Scopimera bitympana</i> Shen, 1930										+	
<i>Scopimera globosa</i> (de Haan, 1835) [= <i>S. tuberculata</i>]					+					+	
<i>Scopimera longidactyla</i> Shen, 1932										+	
<i>Tmethypocoelis ceratophora</i> (Koelbel, 1897)										+	
Family Macrophthalmidae											
<i>Macrophthalmus</i> (<i>Macrophthalmus</i>) <i>brevis</i> (Herbst, 1804) [= <i>M. simdentatus</i>]					+					+	
<i>Macrophthalmus</i> (<i>Macrophthalmus</i>) <i>convexus</i> Stimpson, 1858										+	
<i>Macrophthalmus</i> (<i>Macrophthalmus</i>) <i>crassipes</i> H. Milne Edwards, 1852										+	
<i>Macrophthalmus</i> (<i>Macrophthalmus</i>) <i>milloti</i> Crosnier, 1965					+						
<i>Macrophthalmus</i> (<i>Mareotis</i>) <i>crinitus</i> Rathbun, 1913										+	
<i>Macrophthalmus</i> (<i>Mareotis</i>) <i>definitus</i> Adams et White, 1849										+	
<i>Macrophthalmus</i> (<i>Mareotis</i>) <i>pacificus</i> Dana, 1851										+	
<i>Macrophthalmus</i> (<i>Mareotis</i>) <i>tomentosus</i> Eydoux et Souleyet, 1842										+	
<i>Macrophthalmus</i> (<i>Paramareotis</i>) <i>erato</i> de Man, 1888										+	
<i>Macrophthalmus dilatatus sulcatus</i> H. Milne Edwards, 1852 [as <i>M. dilatatus</i>]										+	
Family Mictyridae											
<i>Mictyris brevidactylus</i> Stimpson, 1858					+						
<i>Mictyris longicarpus</i> Latreille, 1806					+					+	
Family Ocypodidae											
<i>Ocypode ceratophthalmus</i> (Pallas, 1772) [= <i>O. ceratophthalma</i>]					+		+		+	+	
<i>Ocypode convexa</i> Quoy et Gaimard, 1824					+						
<i>Ocypode cordimanus</i> Latreille, 1818					+						
<i>Ocypode kublii</i> de Haan, 1835					+						
<i>Ocypode</i> sp.										+	
<i>Uca</i> (<i>Austruca</i>) <i>annulipes</i> (H. Milne Edwards, 1837)					+						
<i>Uca</i> (<i>Austruca</i>) <i>lactea</i> (de Haan, 1835)					+					+	
<i>Uca</i> (<i>Gelasimus</i>) <i>borealis</i> Crane, 1975					+						
<i>Uca</i> (<i>Gelasimus</i>) <i>tetragonon</i> (Herbst, 1790)					+						
<i>Uca</i> (<i>Gelasimus</i>) <i>vocans</i> (Linnaeus, 1758) [= <i>U. marionis</i>]					+					+	
<i>Uca</i> (<i>Paraleptuca</i>) <i>crassipes</i> (White, 1847)					+						
<i>Uca</i> (<i>Tubuca</i>) <i>arcuata</i> (de Haan, 1835)					+					+	
<i>Uca</i> (<i>Tubuca</i>) <i>dussumieri</i> (H. Milne Edwards, 1852) [= <i>U. (Dultuca) dussumieri</i>]										+	
<i>Uca</i> (<i>Tubuca</i>) <i>flamula</i> Crane, 1975				+							
<i>Uca</i> (<i>Tubuca</i>) <i>forcipata</i> (Adams et White, 1849)				+						+	
<i>Uca</i> (<i>Tubuca</i>) <i>paradussumieri</i> Bott, 1973				+							
<i>Uca</i> (<i>Tubuca</i>) <i>rosea</i> (Tweedie, 1937)					+						
<i>Uca</i> (<i>Tubuca</i>) <i>urvillei</i> (H. Milne Edwards, 1852)					+						
<i>Uca</i> spp. [as <i>Uca dubia</i>]					+					+	

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Xenophthalmidae											
<i>Neoxenophthalmus obscurus</i> (Henderson, 1893) [= <i>Xenophthalmus obscurus</i>]											+
Family Pinnotheridae											
<i>Pinnotheres boninensis</i> Stimpson, 1858					+						
<i>Pinnotheres obscurus</i> Stimpson, 1858					+						+
<i>Pinnotheres</i> sp.											+
Phylum MOLLUSCA											
Class POLYPLACOPHORA											
Order CHITONIDA											
Family Chitonidae											
<i>Liolophura</i> sp.					+						
<i>Lucilina lamellosa</i> (Quoy et Gaimard, 1835)					+						
<i>Lucilina tenuicostata</i> Sirenko, 2016											+
<i>Lucilina</i> sp.									+		
<i>Onithochiton helenae vietnamensis</i> Sirenko, 2016									+		
<i>Onithochiton stracki</i> Sirenko, 2012					+						
<i>Rhyssoplax pulcherrimus</i> (Sowerby II, 1842)					+						
<i>Tonicia</i> sp.					+						
Family Acanthochitonidae											
<i>Acanthochitona britayevi</i> Sirenko, 2012					+						
<i>Acanthochitona fascicularis</i> (Linnaeus, 1767) [= <i>A. communis</i>]					+						
<i>Acanthochitona</i> sp.					+						
<i>Notoplax</i> spp.				+					+		
Family Cryptoplacidae											
<i>Cryptoplax larvaeformis</i> (Burrow, 1815)					+						
<i>Cryptoplax</i> spp.					+				+		
Family Ischnochitonidae											
<i>Ischnochiton</i> sp.					+						
Family Mopaliidae											
* <i>Plaxiphora bucklandnicksi</i> Sirenko, 2012					+						
<i>Plaxiphora</i> spp.				+					+		
Class GASTROPODA											
Clade PATELLOGASTROPODA											
Family Patellidae											
<i>Scutellastra flexuosa</i> (Quoy et Gaimard, 1834) [= <i>Patella flexuosa flexuosa</i>]					+						
<i>Scutellastra optima</i> (Pilsbry, 1927) [= <i>Patella stellaeformis optima</i>]					+						
Family Acmaeidae											
<i>Acmaea</i> sp.											+
Family Lottiidae											
<i>Lottia pelta</i> (Rathke, 1833) [= <i>Acmaea pelta</i>]											+
<i>Patelloida saccharina</i> (Linnaeus, 1758) [= <i>Acmaea saccharina</i>]	+	+		+	+						+
<i>Patelloida striata</i> Quoy et Gaimard, 1834					+						
Lottiidae gen. sp.					+						
Family Nacellidae											
<i>Cellana rota</i> (Gmelin, 1791) [= <i>C. variegata</i> , <i>Patella aster</i>]					+	+					
<i>Cellana testudinaria</i> (Linnaeus, 1758) [= <i>Patella testudinaria</i>]	+	+	+		+			+	+	+	

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Cellana toreuma</i> (Reeve, 1854)	+				+		+	+			
<i>Cellana vitiensis</i> Powell, 1973 [= <i>C. sagittata</i>]							+	+			
<i>Cellana</i> spp. [as <i>C. amussitata</i>]	+				+					+	
Clade VETIGASTROPODA											
Family Fissurellidae											
<i>Diodora quadriradiata</i> (Reeve, 1850)			+								
<i>Scutus anatinus</i> (Donovan, 1820) [= <i>S. australis</i>]					+						
<i>Scutus antipodes</i> Montfort, 1810 [= <i>S. elongatus</i>]					+				+		
<i>Scutus unguis</i> (Linnaeus, 1758)					+						
Family Haliotidae											
<i>Haliotis asinina</i> Linnaeus, 1758	+				+						
<i>Haliotis diversicolor</i> Reeve, 1846										+	
<i>Haliotis ovina</i> Gmelin, 1791	+				+					+	
<i>Haliotis varia</i> Linnaeus, 1758					+						
Family Tegulidae											
<i>Chlorostoma xanthostigma</i> (A. Adams, 1853) [= <i>Tegula xanthostigma</i>]										+	
<i>Tectus conus</i> (Gmelin, 1791)					+						
* <i>Tectus niloticus</i> (Linnaeus, 1767) [= <i>Trochus niloticus</i>]				+	+						
<i>Tectus pyramis</i> (Born, 1778)	+				+						
<i>Tegula rustica colliculus</i> Sowerby III, 1913								+			
Family Trochidae											
<i>Clanculus denticulatus</i> (Gray, 1827)	+										
<i>Clanculus edentulus</i> (A. Adams, 1853) [= <i>Euchelus edentulus</i>]	+				+						
<i>Clanculus samoensis</i> (Hombron et Jacquinot, 1848) [= <i>C. atropurpureus</i>]	+				+						
<i>Clanculus</i> sp.					+						
<i>Eurytrochus danieli</i> (Crosse, 1862)					+						
<i>Monodonta canalifera</i> Lamarck, 1816		+									
<i>Monodonta labio</i> (Linnaeus, 1758)	+			+	+		+	+		+	
<i>Monodonta</i> sp.					+						
<i>Trochus intextus</i> Kiener, 1850 [= <i>T. sandwichiensis</i>]					+					+	
<i>Trochus maculatus</i> Linnaeus, 1758	+			+	+	+	+	+	+	+	
<i>Umbonium thomasi</i> (Crosse, 1863)										+	
<i>Umbonium vestiarius</i> (Linnaeus, 1758)					+						
<i>Umbonium</i> sp.										+	
Family Turbinidae											
<i>Angaria delphinus</i> (Linnaeus, 1758)	+				+						
<i>Astralium rhodostomum</i> (Lamarck, 1822) [= <i>Astraea rhodostoma</i>]					+						
<i>Astralium</i> sp.					+						
<i>Lunella coronata</i> (Gmelin, 1791) [= <i>Turbo coronatus</i>]										+	
<i>Lunella granulata</i> (Gmelin, 1791)										+	
<i>Turbo bruneus</i> (Röding, 1798)	+				+						
<i>Turbo chrysostomus</i> Linnaeus, 1758					+						
<i>Turbo</i> sp.							+				

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Clade NERITIMORPHA											
Family Neritidae											
<i>Clithon faba</i> (Sowerby I, 1836)					+						
<i>Clithon oualaniense</i> (Lesson, 1831) [= <i>Theodoxus oualaniense</i>]					+						
<i>Nerita albicilla</i> Linnaeus, 1758	+	+		+	+	+	+	+	+	+	
<i>Nerita balteata</i> Reeve, 1855 [= <i>N. lineata</i>]	+	+		+	+					+	
<i>Nerita chamaeleon</i> Linnaeus, 1758					+						
<i>Nerita costata</i> Gmelin, 1791		+		+	+						
<i>Nerita insculpta</i> Récluz, 1841						+	+	+		+	
<i>Nerita plicata</i> Linnaeus, 1758				+	+	+	+	+			
<i>Nerita polita</i> Linnaeus, 1758					+						
<i>Nerita signata</i> Lamarck, 1822 [= <i>N. siquata</i>]										+	
<i>Nerita squamulata</i> Le Guillou, 1841					+						
<i>Nerita undata</i> Linnaeus, 1758					+						
<i>Nerita</i> spp.					+		+			+	
<i>Neritina auriculata</i> Lamarck, 1816					+						
<i>Neritina cornucopia</i> (Benson, 1836)					+						
<i>Neritina violacea</i> (Gmelin, 1791) [= <i>N. crepidularia</i>]										+	
<i>Neritina</i> spp.										+	
<i>Theodoxus</i> sp.					+						
Clade CAENOCASTROPODA											
Family Cerithiidae											
<i>Cerithium citrinum</i> Sowerby II, 1855	+			+							
<i>Cerithium columna</i> Sowerby I, 1834					+	+		+			
<i>Cerithium coralium</i> Kiener, 1841 [= <i>C. ustum</i>]					+						
<i>Cerithium punctatum</i> Bruguière, 1792 [= <i>C. piperitum</i>]	+			+	+						
<i>Cerithium traillii</i> Sowerby II, 1855 [= <i>Clypeomorus traillii</i>]					+						
<i>Cerithium zonatum</i> (Wood, 1828) [= <i>C. gentile</i>]					+						
<i>Cerithium</i> sp.					+						
<i>Clypeomorus batillariaeformis</i> Habe et Kosuge, 1966 [= <i>C. moniliferum</i> , <i>Cerithium moniliferum</i> , <i>C. obscurum</i>]	+				+					+	
<i>Clypeomorus bifasciata</i> (Sowerby II, 1855) [= <i>C. morus</i> , <i>Cerithium morus</i> , <i>C. gemmulatum</i>]		+		+	+	+	+	+		+	
<i>Clypeomorus inflata</i> (Quoy et Gaimard, 1834)					+						
<i>Clypeomorus irrorata</i> (Gould, 1849) [= <i>Cerithium repletulum</i>]					+						
<i>Clypeomorus nympha</i> Houbrick, 1985 [= <i>Cerithium sejunctum</i>]										+	
<i>Clypeomorus pellucida</i> (Hombron et Jacquinot, 1852) [= <i>Cerithium patulum</i>]					+						
<i>Clypeomorus petrosa chemnitziana</i> (Pilsbry, 1901) [= <i>Cerithium chemnitzianum</i>]					+						
<i>Clypeomorus subbrevicula</i> (Oöstingh, 1925) [= <i>Cerithium subbreviculum</i>]					+						
<i>Clypeomorus</i> sp.					+						
<i>Rhinoclavis articulata</i> (A. Adams et Reeve, 1850)			+		+						
<i>Rhinoclavis aspera</i> (Linnaeus, 1758)					+						
<i>Rhinoclavis sinensis</i> (Gmelin, 1791) [= <i>Cerithium sinensis</i>]					+					+	
<i>Rhinoclavis vertagus</i> (Linnaeus, 1767)					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Modulidae											
<i>Indomodulus tectum</i> (Gmelin, 1791)					+						
Family Batillariidae											
<i>Batillaria australis</i> (Quoy et Gaimard, 1834)					+					+	
<i>Batillaria sordida</i> (Gmelin, 1791)										+	
[= <i>Cerithium bornii</i> , as <i>Clypeomorus bornei</i>]											
<i>Batillaria zonalis</i> (Bruguère, 1792)					+					+	
Family Planaxidae											
<i>Planaxis sulcatus</i> (Born, 1778)		+	+		+	+	+	+	+	+	
<i>Supplanaxis niger</i> (Quoy et Gaimard, 1833) [= <i>Planaxis niger</i>]	+				+						
Family Potamididae											
<i>Cerithidea quoyii</i> (Hombron et Jacquinot, 1848)					+						
<i>Cerithidea sinensis</i> (Philippi, 1848)					+						
<i>Cerithideopsilla cingulata</i> (Gmelin, 1791)					+					+	
[= <i>Cerithidea cingulata</i>]											
<i>Cerithideopsilla djadjariensis</i> (K. Martin, 1899)					+						
<i>Cerithideopsilla microptera</i> (Kiener, 1842)					+						
<i>Terebralia palustris</i> (Linnaeus, 1767)					+						
<i>Terebralia sulcata</i> (Born, 1774)					+					+	
Family Thiaridae											
<i>Sermyla riqueti</i> (Grateloup, 1840)					+						
Family Turritellidae											
<i>Neobaustator fortilirata</i> (Sowerby III, 1914)										+	
[= <i>Turritella fortilirata</i>]											
<i>Turritella bacillum</i> Kiener, 1844					+					+	
Family Calyptraeidae											
<i>Ergaea walshi</i> (Reeve, 1859) [= <i>Crepidula scabies</i>]					+						
Family Cypraeidae											
<i>Cypraea tigris</i> Linnaeus, 1758					+						
<i>Cypraea</i> spp.					+		+				
<i>Erosaria erosa</i> (Linnaeus, 1758)					+						
<i>Erosaria helvola</i> (Linnaeus, 1758)					+	+					
<i>Erosaria lamarckii</i> (Gray, 1825)					+						
<i>Erosaria poraria</i> (Linnaeus, 1758)					+						
<i>Erronea erronea</i> (Linnaeus, 1758)					+						
<i>Luria isabella</i> (Linnaeus, 1758)					+						
<i>Lyncina carneola</i> (Linnaeus, 1758)				+	+						
<i>Lyncina vitellus</i> (Linnaeus, 1758) [= <i>Cypraea vitellus</i>]					+						
* <i>Mauritia arabica</i> (Linnaeus, 1758)											
[= <i>Monetaria arabica</i> , <i>Cypraea arabica</i>]	+			+	+	+			+		
<i>Mauritia scurra</i> (Gmelin, 1791) [as <i>M. amarata</i>]					+						
<i>Monetaria annulus</i> (Linnaeus, 1758) [= <i>Cypraea annulus</i>]					+	+		+			
<i>Monetaria caputserpentis</i> (Linnaeus, 1758)					+	+					
[= <i>Erosaria caputserpentis</i>]											
<i>Monetaria moneta</i> (Linnaeus, 1758)				+	+	+		+			
<i>Purpuradusta fimbriata</i> (Gmelin, 1791)					+						
[= <i>Palmadusta fimbriata</i>]											

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Ovulidae											
<i>Ovula ovum</i> (Linnaeus, 1758) [= <i>Amphiperas ovum</i>]					+						
Family Littorinidae											
<i>Echinolittorina feejeensis</i> (Reeve, 1857)					+						
<i>Echinolittorina melanacme</i> (E.A. Smith, 1876) [= <i>Littorina melanacme</i>]										+	
<i>Echinolittorina miliaris</i> (Quoy et Gaimard, 1833) [= <i>Nodilittorina granularis</i> , <i>Littorina granularis</i> , <i>Tectarius granularis</i>]					+	+				+	
<i>Echinolittorina millegrana</i> (Philippi, 1848) [= <i>Nodilittorina millegrana</i>]	+		+	+	+	+	+	+			
<i>Echinolittorina novaezelandiae</i> (Reeve, 1857) [= <i>Tectarius novae-zelandiae</i>]					+						
<i>Echinolittorina pascua</i> (Rosewater, 1970)					+						
<i>Echinolittorina vidua</i> (Gould, 1859) [= <i>Littorina ventricosa</i>]	+				+						
<i>Littoraria ardouiniana</i> (Heude, 1885)					+						
<i>Littoraria articulata</i> (Philippi, 1846)					+						
<i>Littoraria carinifera</i> (Menke, 1830)					+						
<i>Littoraria intermedia</i> (Philippi, 1846)					+						
<i>Littoraria lutea</i> (Philippi, 1847)					+						
<i>Littoraria melanostoma</i> (Gray, 1839) [= <i>Littorina melanostoma</i> , <i>Melarbaphe melanostoma</i>]					+					+	
<i>Littoraria pallescens</i> (Philippi, 1846)					+						
<i>Littoraria scabra</i> (Linnaeus, 1758) [= <i>Littorina scabra</i>]		+			+	+	+	+		+	
<i>Littoraria undulata</i> (Gray, 1839) [= <i>Littorina undulata</i>]					+						
<i>Littorinopsis</i> sp.										+	
<i>Nodilittorina pyramidalis</i> (Quoy et Gaimard, 1833)					+	+					
<i>Peasiella</i> sp.					+						
<i>Tectarius antonii</i> (Philippi, 1846) [= <i>Tectininus nodulosus</i>]	+	+			+	+					
<i>Tectarius</i> spp.					+					+	
Family Tonnidae											
<i>Tonna sulcosa</i> (Born, 1778)					+						
Family Naticidae											
<i>Mammilla melanostoma</i> (Gmelin, 1791) [= <i>Polinices melanostoma</i>]					+						
<i>Natica vitellus</i> (Linnaeus, 1758)					+						
<i>Natica</i> spp.					+					+	
<i>Notocochlis gualteriana</i> (Récluz, 1844)					+						
<i>Polinices flemingianus</i> (Récluz, 1844)					+						
<i>Polinices mammilla</i> (Linnaeus, 1758) [= <i>P. tumidus</i>]	+				+						
<i>Tanea areolata</i> (Récluz, 1844) [= <i>Natica areolata</i>]					+						
Naticidae gen. sp.					+						
Family Assimineidae											
<i>Assimineae</i> spp.					+					+	
<i>Metassiminea philippinica</i> (O. Böettger, 1887)					+						
Assimineidae gen. sp.					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Stenothyridae											
<i>Stenothyra</i> sp.					+						
Family Strombidae											
<i>Canarium mutabile</i> (Swainson, 1821) [= <i>Strombus mutabilis</i>]						+		+			
<i>Canarium urceus</i> (Linnaeus, 1758) [= <i>Strombus urceus</i>]					+						
<i>Conomurex lubuanus</i> (Linnaeus, 1758) [= <i>Strombus lubuanus</i>]					+						
<i>Laevistrombus turturella</i> (Röding, 1798) [= <i>Strombus isabella</i>]										+	
* <i>Lambis lambis</i> (Linnaeus, 1758) [= <i>Pterocera lambis</i>]				+	+						
<i>Lambis scorpius</i> (Linnaeus, 1758) [= <i>Pterocera scorpius</i>]					+						
<i>Lambis</i> sp.							+				
<i>Strombus</i> spp.					+					+	
Family Bursidae											
<i>Bursa asperrima</i> Dunker, 1862					+						
<i>Bursa bufonia</i> (Gmelin, 1791)					+						
<i>Bursa granularis</i> (Röding, 1798) [= <i>B. granifera</i>]					+						
<i>Bursa</i> sp.					+						
Family Ranellidae											
<i>Cymatium</i> sp.					+						
<i>Gutturium muricinum</i> (Röding, 1798) [= <i>Cymatium muricinum</i>]					+						
<i>Gyrineum bituberculare</i> (Lamarck 1816) [as <i>Argobuccinum bituberculare</i>]					+						
<i>Monoplex gemmatus</i> (Reeve, 1844) [= <i>Cymatium gemmatum</i> , <i>Septa gemmata</i>]					+						
<i>Monoplex pilearis</i> (Linnaeus, 1758) [= <i>Cymatium pileare</i> , as <i>Lampusia pileare</i>]					+						
<i>Monoplex vespaeus</i> (Lamarck, 1822) [= <i>Cymatium vespaeum</i> , as <i>Turritriton vespaeum</i>]					+						
<i>Reticutriton pfeifferianus</i> (Reeve, 1844) [= <i>Cymatium pfeifferianum</i>]				+							
Family Personidae											
<i>Distorsio anus</i> (Linnaeus, 1758)					+						
Family Epitoniidae											
<i>Epitonium</i> sp.					+						
Family Hipponicidae											
<i>Antisabia foliacea</i> (Quoy et Gaimard, 1835)					+						
<i>Sabia conica</i> (Schumacher, 1817) [= <i>Hipponix conicus</i>]				+	+						
Family Vermetidae											
<i>Dendropoma corrodens</i> (d'Orbigny, 1841) [= <i>D. annulatus</i>]					+						
<i>Dendropoma planorbis</i> (Dunker, 1860) [= <i>Vermetus planorbis</i> , as <i>Spiroglyphus planorbis</i>]		+	+		+		+				
<i>Dendropoma</i> spp.		+			+						
<i>Thylacodes</i> sp. [= <i>Serpulorbis</i> sp.]					+						
<i>Vermetus tokyoensis</i> (Pilsbry, 1895) [= <i>Macrophragmus tokyoensis</i>]				+			+				
Family Olividae											
<i>Oliva oliva</i> (Linnaeus, 1758)					+						
<i>Oliva</i> sp.					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Terebridae											
<i>Terebra</i> sp.					+						
Family Buccinidae											
<i>Cantharus</i> sp. [as <i>C. puncticulatus</i>]					+						
<i>Engina lineata</i> (Reeve, 1846)					+						
<i>Engina mendicaria</i> (Linnaeus, 1758)					+						
<i>Pollia fumosa</i> (Dillwyn, 1817) [= <i>Cantharus fumosus</i>]	+				+	+		+			
<i>Pollia undosa</i> (Linnaeus, 1758) [= <i>Cantharus undosus</i>]					+	+	+	+			
Family Columbellidae											
<i>Euplica scripta</i> (Lamarck, 1822)											
[= <i>E. versicolor</i> , <i>Columbella versicolor</i>]	+			+	+						
<i>Euplica</i> sp.					+						
<i>Mitrella essingtonensis</i> (Reeve, 1859)											
[= <i>Pyrene essingtonensis</i> , <i>Columbella essingtonensis</i>]	+										
<i>Mitrella puella</i> (Sowerby I, 1844)											
[= <i>Pyrene iodostoma</i> , <i>Columbella iodostoma</i>]	+										
<i>Mitrella scripta</i> (Linnaeus, 1758) [= <i>Pyrene scripta</i>]					+	+					
<i>Pardalinops testudinaria</i> (Link, 1807)											
[= <i>Pyrene pardalina</i> , <i>P. testudinaria</i> , <i>Columbella pardalina</i>]				+	+	+					
<i>Pictocolumbella ocellata</i> (Link, 1807)											
[= <i>Pyrene ocellata</i> , <i>Columbella fulgurans</i> , as <i>Pyrene fulgurans</i>]		+		+	+	+		+			
<i>Pyrene punctata</i> (Bruguière, 1789)					+	+					
[= <i>P. discors</i> , as <i>Columbella discors</i>]					+	+					
<i>Pyrene splendidula</i> (Sowerby I, 1844)	+										
<i>Pyrene</i> sp.						+					
<i>Zemitrella sulcata</i> (Hutton, 1873) [= <i>Columbella varians</i>]						+					
Family Fasciariidae											
<i>Fusinus filiosus</i> (Schubert et Wagner, 1829) [= <i>Latirus filiosus</i>]	+										
<i>Latirolagena smaragdulus</i> (Linnaeus, 1758)				+							
<i>Latirus barclayi</i> (Reeve, 1847)							+				
<i>Latirus polygonus</i> (Gmelin, 1791)						+					
<i>Latirus</i> spp. [= <i>Lathyrus</i> sp.]						+	+		+		
<i>Nodolatirus nodatus</i> (Gmelin, 1791) [= <i>Latirus nodatus</i>]						+					
<i>Peristernia nassatula</i> (Lamarck, 1822)						+					
<i>Peristernia ustulata</i> (Reeve, 1847)				+							
<i>Turritatirus turritus</i> (Gmelin, 1791) [= <i>Latirus turritus</i>]					+						
Family Melongenidae											
<i>Volegalea cochlidium</i> (Linnaeus, 1758)						+					
[= <i>Pugilina pugilina</i> , as <i>P. cochlidium</i> , <i>Galeodes pugilina</i>]										+	
Family Nassariidae											
<i>Cyclope neritea</i> (Linnaeus, 1758) [= <i>Nassa nerita</i>]					+						
<i>Nassarius bellulus</i> (A. Adams, 1852)										+	
<i>Nassarius gaudiosus</i> (Hinds, 1844)					+						
<i>Nassarius graphiterus</i> (Hombron et Jacquinot, 1848)					+						
[= <i>N. luridus</i>]											
<i>Nassarius hirtus</i> (Kiener, 1834)										+	
<i>Nassarius olivaceus</i> (Bruguière, 1789) [= <i>N. taenioides</i>]					+					+	

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Nassarius pullus</i> (Linnaeus, 1758) [= <i>N. thesites</i>]					+					+	
<i>Nassarius</i> spp. [= <i>Nassa</i> sp., <i>Alectrion</i> sp., <i>Hima</i> sp., as <i>Nassarius corculata</i> , <i>N. pertus</i>]					+					+	
Family Muricidae											
<i>Chicoreus brunneus</i> (Link, 1807) [= <i>Murex adustus</i>]					+						
<i>Chicoreus capucinus</i> (Lamarck, 1822) [= <i>Murex capucinus</i>]					+						
<i>Chicoreus microphyllus</i> (Lamarck, 1816) [= <i>Murex microphyllus</i>]					+						
<i>Chicoreus</i> sp.					+						
<i>Coralliophila bulbiformis</i> (T.A. Conrad, 1837) [= <i>C. gibbosa</i>]					+						
<i>Coralliophila monodonta</i> (Blainville, 1832) [= <i>C. madreporarum</i> , <i>Quoyula madreporarum</i>]					+						
<i>Coralliophila violacea</i> (Kiener, 1836) [= <i>C. neritoidea</i>]					+						
<i>Coralliophila</i> sp.					+						
<i>Drupa morum</i> Röding, 1798			+	+	+						
<i>Drupa nodus</i> Gmelin, 1791				+	+						
<i>Drupa ricinus</i> (Linnaeus, 1758) [= <i>Ricinula arachnoides</i>]					+						
<i>Drupa rubusidaeus</i> Röding 1798					+						
<i>Drupa</i> spp. [as <i>D. muricoides</i>]				+	+						
<i>Drupella cornus</i> (Röding, 1798) [= <i>Drupa elata</i>]					+						
<i>Drupella margariticola</i> (Broderip in Broderip et Sowerby, 1833) [= <i>Cronia margariticola</i> , <i>Drupa margariticola</i> , <i>Morula margariticola</i> , as <i>M. undata</i>]	+			+	+	+	+	+		+	
<i>Drupella rugosa</i> (Born, 1778) [= <i>Murex rugosa</i> , <i>Thais rugosa</i> , <i>Morula concatenata</i> , <i>Drupa concatenata</i>]					+	+		+	+		+
<i>Drupina grossularia</i> (Röding, 1798) [= <i>Drupa grossularia</i>]					+						
<i>Ergalatax</i> sp.					+						
<i>Indothais blanfordi</i> (Melville, 1893) [= <i>Thais</i> (<i>Thaisella</i>) <i>blanfordi</i>]										+	
<i>Indothais gradata</i> (Jonas, 1846) [= <i>Thais</i> (<i>Thaisella</i>) <i>gradata</i>]					+						
<i>Indothais javanica</i> (Philippi, 1848) [= <i>Thais</i> (<i>Thaisella</i>) <i>javanica</i>]					+						
<i>Magilus antiquus</i> Montfort, 1810 [= <i>M. maillardi</i> , as <i>Coralliobia maillardi</i>]					+						
<i>Mancinella alouina</i> (Röding, 1798) [= <i>Thais mancinella</i>]			+		+		+	+			
<i>Mancinella armigera</i> Link, 1807 [= <i>Thais armigera</i>]			+		+						
<i>Mancinella echinata</i> (Blainville, 1832) [= <i>Thais echinata</i>]					+						
<i>Mancinella echinulata</i> (Lamarck, 1822) [= <i>Thais echinulata</i>]	+				+						
<i>Menathais tuberosa</i> (Röding, 1798) [= <i>Thais pica</i> , <i>Th. tuberosa</i>]			+	+	+						
<i>Morula anaxares</i> (Kiener, 1836) [= <i>Drupa anaxares</i>]					+						
<i>Morula aspera</i> (Lamarck, 1816)					+						
<i>Morula biconica</i> (Blainville, 1832) [= <i>Drupa biconica</i>]					+						
<i>Murex pecten</i> Lightfoot, 1786 [= <i>M. triremis</i>]					+					+	
<i>Murex</i> spp.					+					+	
<i>Muricodrupa fiscella</i> (Gmelin, 1791) [= <i>Drupa fiscella</i> , <i>D. decussata</i> , <i>Morula fiscella</i> , <i>Cronia fiscella</i> , as <i>C. decussata</i>]					+					+	
<i>Nassa sarta</i> (Bruguère, 1789)					+						
<i>Nassa</i> sp.					+						
<i>Oppomorus purpureocinctus</i> (Preston, 1909) [= <i>Engina purpureocincta</i>]				+							

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Pascula ochrostoma</i> (Blainville, 1832) [= <i>Drupa ochrostoma</i>]					+						
<i>Purpura persica</i> (Linnaeus, 1758) [= <i>P. rudolphi</i> , <i>Thais rudolphi</i>]					+						
<i>Reishia clavigera</i> (Küster, 1860) [= <i>Thais clavigera</i>]										+	
<i>Reishia luteostoma</i> (Holten, 1803) [= <i>Thais luteostoma</i> , as <i>Purpura luteostoma</i>]		+	+		+					+	
<i>Semiricinula muricina</i> (Blainville, 1832) [= <i>Cronia muricina</i>]					+						
<i>Semiricinula turbinoides</i> (Blainville, 1832)					+						
<i>Tenguella granulata</i> (Duclos, 1832) [= <i>Morula granulata</i> , <i>Drupa granulata</i> , <i>D. tuberculata</i>]					+	+	+	+	+	+	
<i>Tenguella musiva</i> (Kiener, 1835) [= <i>Morula musiva</i> , as <i>Drupa musiva</i>]		+			+		+			+	
<i>Thais</i> sp.					+						
<i>Thalessa aculeata</i> (Deshayes, 1844) [= <i>Thais aculeata</i>]	+			+	+		+				
Family Costellariidae											
<i>Vexillum rugosum</i> (Gmelin, 1791)					+						
<i>Vexillum virgo</i> (Linnaeus, 1767) [= <i>V. cruentatum</i>]					+						
Family Mitridae											
<i>Mitra ambigua</i> Swainson, 1829					+						
<i>Mitra chrysalis</i> Reeve, 1844					+						
<i>Mitra ferruginea</i> Lamarck, 1811					+						
<i>Mitra fraga</i> Quoy et Gaimard, 1833					+						
<i>Mitra litterata</i> Lamarck, 1811 [= <i>Strigatella litterata</i>]					+						
<i>Mitra paupercula</i> (Linnaeus, 1758) [= <i>M. zebra</i>]					+						
<i>Mitra scutulata</i> (Gmelin, 1791) [= <i>Strigatella scutulata</i>]		+			+						
<i>Mitra</i> spp.					+					+	
Family Pseudomelatomidae											
<i>Inquisitor varicosa</i> (Reeve, 1843)				+							
Family Turbinellidae											
<i>Vasum turbinellus</i> (Linnaeus, 1758)					+	+					
Family Volutidae											
<i>Voluta</i> sp.					+						
Family Conidae											
<i>Conus arenatus</i> Hwass in Bruguière, 1792					+						
<i>Conus capitaneus</i> Linnaeus, 1758					+						
<i>Conus chaldaeus</i> (Röding, 1798)					+	+					
<i>Conus consors</i> Sowerby I, 1833					+						
<i>Conus coronatus</i> Gmelin, 1791					+						
<i>Conus distans</i> Hwass in Bruguière, 1792					+						
<i>Conus ebraeus</i> Linnaeus, 1758					+	+	+		+		
<i>Conus eburneus</i> Hwass in Bruguière, 1792					+						
<i>Conus flavidus</i> Lamarck, 1810					+	+			+		
<i>Conus lividus</i> Hwass in Bruguière, 1792					+	+	+				
<i>Conus marmoreus</i> Linnaeus, 1758					+						
<i>Conus miles</i> Linnaeus, 1758					+						
<i>Conus muriculatus</i> Sowerby I, 1833 [= <i>C. sugillatus</i>]					+						
<i>Conus musicus</i> Hwass in Bruguière, 1792 [= <i>C. ceylanensis</i>]					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Conus nussatella</i> Linnaeus, 1758					+						
<i>Conus pulicarius</i> Hwass in Bruguière, 1792					+						
<i>Conus rattus</i> Hwass in Bruguière, 1792					+						
<i>Conus sponsalis</i> Hwass in Bruguière, 1792				+	+						
<i>Conus striatus</i> Linnaeus, 1758					+						
<i>Conus textile</i> Linnaeus, 1758					+						
<i>Conus</i> spp.				+	+		+				
Family Eulimidae											
<i>Eulima</i> sp.					+						
<i>Melanella soliduloides</i> (Habe, 1951) [= <i>Balcis soliduloides</i>]					+						
Family Triphoridae											
<i>Mastonia rubra</i> (Hinds, 1843)		+			+						
<i>Mastonia</i> sp.					+						
<i>Strobiligera inflata</i> (Watson, 1880) [= <i>Cerithium inflatum</i>]					+						
<i>Triphora</i> sp. [= <i>Triphoris</i> sp.]					+						
Clade HETEROBRANCHIA											
Family Pyramidellidae											
<i>Milda</i> sp.					+						
<i>Otopleura auriscati</i> (Holten, 1802)					+						
<i>Pyramidella</i> sp.		+									
Pyramidellidae gen. sp.					+						
Family Siphonariidae											
<i>Siphonaria atra</i> Quoy et Gaimard, 1833 [= <i>S. atra</i> var. <i>coreensis</i>]					+						
<i>Siphonaria corrugata</i> Reeve, 1856					+						
<i>Siphonaria japonica</i> (Donovan, 1824) [= <i>S. cochleariformis</i>]					+						
<i>Siphonaria sirius</i> Pilsbry, 1894					+						
<i>Siphonaria subatra</i> Pilsbry, 1904					+						
<i>Siphonaria</i> spp.		+			+					+	
Family Bullidae											
<i>Bulla</i> sp.					+						
Family Haminoeidae											
<i>Atys naucum</i> (Linnaeus, 1758)					+						
<i>Phanerophthalmus smaragdinus</i> (Rüppel et Leuckart, 1828)					+						
Family Aplysiidae											
<i>Aplysia</i> spp.					+	+					
Family Plakobranchidae											
<i>Elysia pusilla</i> (Bergh, 1872)					+						
<i>Elysia</i> sp.					+						
Family Bornellidae											
<i>Bornella stellifer</i> (A. Adams et Reeve in A. Adams, 1848)					+						
[= <i>B. arborescens</i> , <i>B. digitata</i>]											
Family Cadlinidae											
<i>Aldisa</i> sp. [as <i>A. nhatrangensis</i>]					+						
Family Chromodorididae											
<i>Chromodoris quadricolor</i> (Rüppel et Leuckart, 1830)					+						
[= <i>Glossodoris quadricolor</i>]											

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Dendrodorididae											
<i>Dendrodoris elongata</i> Baba, 1936					+						
Family Discodorididae											
<i>Platydorhis cruenta</i> (Quoy et Gaimard, 1832)					+						
Family Facelinidae											
<i>Pteraeolidia ianthina</i> (Angas, 1864)					+						
Family Hexabranchidae											
<i>Hexabranchus sanguineus</i> (Rüppell et Leuckart, 1830) [= <i>H. marginatus</i>]					+						
Family Ellobiidae											
<i>Cassidula nucleus</i> (Gmelin, 1791)					+						
<i>Ellobium chinensis</i> Pfeiffer, 1854										+	
<i>Ellobium</i> sp.										+	
<i>Laemodonta siamensis</i> (Morelet, 1875)					+						
<i>Pythia</i> sp.					+						
Family Onchidiidae											
<i>Onchidium</i> spp.					+					+	
<i>Peronia peronii</i> (Cuvier, 1804) [= <i>Onchidium peronii</i>]					+						
Onchidiidae gen. spp.					+					+	
Class BIVALVIA											
Order ARCIDA											
Family Arcidae											
<i>Acar plicata</i> (Dillwyn, 1817) [= <i>Arca plicata</i>]					+						
<i>Anadara antiquata</i> (Linnaeus, 1758) [= <i>Arca antiquata</i>]					+						
<i>Anadara binakayanensis</i> (Faustino, 1932)										+	
<i>Anadara granosa</i> (Linnaeus, 1758)										+	
<i>Anadara gubernaculum</i> (Reeve, 1844)					+					+	
<i>Anadara</i> cf. <i>satorwi</i> (Dunker, 1882)										+	
<i>Anadara troscheli</i> (Dunker, 1882)										+	
<i>Anadara</i> sp.										+	
<i>Arca navicularis</i> Bruguière, 1789 [as <i>Barbatia navicularis</i>]					+		+				
<i>Arca ventricosa</i> Lamarck, 1819					+						
<i>Arca</i> spp. [as <i>A. subgranulosa</i> , <i>Barbatia imbricata</i>]					+					+	
<i>Barbatia amygdalumtostum</i> (Röding, 1798)					+						
<i>Barbatia cometa</i> (Reeve, 1844) [= <i>Arca cometa</i>]					+		+				
<i>Barbatia foliata</i> (Forsskål, 1775) [= <i>B. lima</i> , <i>B. nivea</i> , <i>Arca nivea</i>]					+		+	+		+	
<i>Barbatia fusca</i> (Bruguière, 1789) [= <i>B. bicolorata</i> , <i>Arca bicolorata</i>]					+						
<i>Barbatia virescens</i> (Reeve, 1844)					+						
<i>Barbatia</i> spp.					+					+	
<i>Striarca symmetrica</i> (Reeve, 1844)					+						
Order MYTILIDA											
Family Mytilidae											
<i>Adula</i> sp.					+						
<i>Botula cinnamomea</i> (Gmelin, 1791) [= <i>Botulopa silicula</i>]					+						
<i>Brachidontes mutabilis</i> (Gould, 1861) [= <i>Hormomya mutabilis</i>]					+		+	+		+	
<i>Brachidontes setiger</i> (Dunker, 1857) [= <i>Modiolus setigera</i>]					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Brachidontes striatulus</i> (Hanley, 1843) [= <i>Modiola striatula</i>]					+						
<i>Brachidontes</i> sp.										+	
<i>Leiosolenus levigatus</i> (Quoy et Gaimard, 1835) [= <i>Lithodomus levigatus</i> , <i>Lithophaga laevigata</i>]			+		+	+	+	+		+	
<i>Leiosolenus lima</i> (Jousseume in Lamy, 1919) [= <i>Lithophaga lima</i>]					+						
<i>Leiosolenus lischkei</i> M. Huber, 2010 [= <i>Lithophagus curtus</i> , as <i>Lithophaga curta</i>]					+						
<i>Leiosolenus malaccanus</i> (Reeve, 1857) [= <i>Lithophaga malaccana</i>]					+		+				
<i>Leiosolenus</i> sp.					+						
<i>Lithophaga caperata</i> (Philippi, 1849) [= <i>L. straminea</i> , <i>L. zitteliana</i>]					+						
<i>Lithophaga teres</i> (Philippi, 1846)					+						
<i>Modiola</i> sp.					+						
<i>Modiolus auriculatus</i> (Krauss, 1848) [= <i>M. agripetus</i> , <i>Modiola auriculata</i>]					+		+				
<i>Modiolus philippinarum</i> (Hanley, 1843)					+						
<i>Musculista senhousia</i> (Benson in Cantor, 1842)					+						
<i>Musculus nanus</i> (Dunker, 1857)											+
<i>Perna</i> spp.				+	+		+				
<i>Septifer bilocularis</i> (Linnaeus, 1758)					+		+				
<i>Septifer excisus</i> (Wiegmann, 1837)					+						
<i>Septifer virgatus</i> (Wiegmann, 1837)							+			+	
<i>Septifer</i> spp.					+					+	
Order PTERIIDA											
Family Pteriidae											
<i>Electroma virens</i> (Lamarck, 1819) [= <i>Avicula georgiana</i> , as <i>Pteria georgiana</i>]					+						
<i>Pinctada imbricata fucata</i> (Gould, 1850) [= <i>P. fucata</i>]					+						
<i>Pinctada maculata</i> (Gould, 1850)					+						
<i>Pinctada margaritifera</i> (Linnaeus, 1758)					+	+					
<i>Pinctada martensii</i> (Dunker, 1872)					+						
<i>Pinctada nigra</i> (Gould, 1850)					+						
<i>Pinctada radiata</i> (Leach, 1814) [as <i>Pinctada imbricata radiata</i>]					+						
<i>Pinctada</i> sp.					+						
<i>Pteria avicular</i> (Holten, 1802) [= <i>P. chinensis</i>]					+						
<i>Pteria maura</i> (Reeve, 1857) [= <i>P. coturnix</i>]					+						
<i>Pteria</i> sp.											+
Family Malleidae											
<i>Malleus legumen</i> Reeve, 1858 [= <i>Malvufundus irregularis</i> , as <i>Parimalleus irregularis</i>]					+					+	
<i>Malleus malleus</i> (Linnaeus, 1758)					+						
<i>Malleus regula</i> (Forsskal in Niebuhr, 1775) [= <i>Malvufundus regulus</i>]					+						
<i>Isognomon australica</i> (Reeve, 1858) [= <i>I. anomioides</i> , <i>Perna anomioides</i>]					+						
<i>Isognomon ephippium</i> (Linnaeus, 1758) [= <i>Perna cumingii</i>]				+	+		+			+	

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
<i>Isognomon isognomum</i> (Linnaeus, 1758) [= <i>I. canina</i> , <i>I. isognomon patibulum</i> , <i>Perna patibulum</i> , <i>P. canina</i>]					+		+				
<i>Isognomon legumen</i> (Gmelin, 1791) [= <i>Perna linguaeformis</i>]					+						
<i>Isognomon nucleus</i> (Lamarck, 1819)					+						
[= <i>Perna nucleus</i> , <i>P. pectinata</i> , as <i>I. quadrangularis</i>]											
<i>Isognomon perna</i> (Linnaeus, 1767) [= <i>I. sulcata</i> , <i>Perna sulcata</i>]					+						
<i>Isognomon</i> spp.				+	+		+				
<i>Perna serratula</i> Reeve, 1858 (<i>nomen dubium</i>)							+				
[as <i>Isognomon serratula</i>]											
Family Pinnidae											
<i>Atrina pectinata</i> (Linnaeus, 1767) [= <i>Pinna pectinata</i>]					+	+					
<i>Atrina strangei</i> (Reeve, 1858) [= <i>Pinna strangei</i>]					+						
<i>Atrina vexillum</i> (Born, 1778) [= <i>Pinna nigra</i> , <i>P. vexillum</i>]					+						
<i>Pinna muricata</i> Linnaeus, 1758 [= <i>P. semicostata</i>]					+						
<i>Pinna saccata</i> Linnaeus, 1758					+						
<i>Pinna</i> spp. [as <i>Pinna canina</i>]					+						+
Order OSTREIDA											
Family Ostreidae											
<i>Dendostrea folium</i> (Linnaeus, 1758)					+					+	
[as <i>Dendostrea foliacea</i> , <i>Ostrea foliolum</i>]											
<i>Dendostrea sandvichensis</i> (Sowerby II, 1871)					+						
[= <i>Ostrea sandwicensis</i>]											
<i>Lopha cristagalli</i> (Linnaeus, 1758) [= <i>Ostrea cristagalli</i>]					+						
<i>Ostrea denselamellosa</i> Lischke, 1869					+						
<i>Ostrea</i> sp.					+						
<i>Saccostrea cucullata</i> (Born, 1778) [= <i>Ostrea forskali</i> , <i>O. cucullata</i>]	+	+		+	+						
<i>Saccostrea echinata</i> (Quoy et Gaimard, 1835)			+		+					+	
[= <i>Ostrea spinosa</i> , <i>O. echinata</i> , as <i>Gryphaea echinata</i>]											
<i>Saccostrea scyphophilla</i> (Peron et Lesueur, 1807) [= <i>S. mordax</i>]	+		+	+	+	+	+	+	+	+	+
<i>Striostrea margaritacea</i> (Lamarck, 1819) [= <i>Ostrea margaritacea</i>]					+						
Family Gryphaeidae											
<i>Hyotissa hyotis</i> (Linnaeus, 1758) [= <i>Pycnodonta hyotis</i>]					+						
Order PECTINIDA											
Family Pectinidae											
<i>Chlamys</i> sp.					+						
<i>Coralichlamys madreporarum</i> (Petit in Sowerby II, 1842)					+						
[= <i>Pecten madreporarum</i>]											
<i>Laevichlamys cuneata</i> (Reeve, 1853) [= <i>Pecten irregularis</i>]					+						
<i>Mimachlamys albolineata</i> (Sowerby II, 1842)					+						
[= <i>Pecten albolineatus</i>]											
Family Spondylidae											
<i>Spondylus lamarckii</i> Chenu, 1845					+						
<i>Spondylus sinensis</i> Schreibers, 1793 [= <i>S. ducalis</i>]					+						
<i>Spondylus squamosus</i> Schreibers, 1793 [= <i>S. cruentus</i>]					+						
<i>Spondylus tenuispinosus</i> Sowerby II, 1847					+						
<i>Spondylus</i> sp. [as <i>S. acutangulis</i>]					+						
Family Anomiidae											
<i>Enigmonia aenigmatica</i> (Holten, 1802) [= <i>Anomia aenigmatica</i>]					+					+	

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Placunidae											
<i>Placuna placenta</i> (Linnaeus, 1758)					+					+	
<i>Placuna</i> sp.										+	
Order LIMIDA											
Family Limidae											
<i>Lima lima</i> (Linnaeus, 1758)					+						
<i>Limaria fragilis</i> (Gmelin, 1791) [= <i>Lima fragilis</i>]					+						
<i>Limaria perfragilis</i> (Habe et Kosuge, 1966) [as <i>Mantellum fragile</i>]					+						
Order VENERIDA											
Family Veneridae											
<i>Anomalocardia</i> sp.										+	
<i>Anomalodiscus squamosus</i> (Linnaeus, 1758) [= <i>Anomalocardia squamosa</i> , <i>Venus squamosa</i>]					+					+	
<i>Circe</i> spp.					+					+	
<i>Cyclina sinensis</i> (Gmelin, 1791)										+	
<i>Dosinia exasperata</i> (Philippi, 1847)					+						
<i>Dosinia troscheli</i> Lischke, 1873 [as <i>Phacosoma troscheli</i>]					+						
<i>Dosinia</i> sp. [as <i>D. sinensis</i>]										+	
<i>Gafrarium dispar</i> (Holten, 1802)					+						
<i>Gafrarium divaricatum</i> (Gmelin, 1791) [= <i>Circe divaricata</i>]					+						
<i>Gafrarium pectinatum</i> (Linnaeus, 1758) [= <i>G. tumidum</i> , <i>Circe pectinata</i> , <i>C. gibba</i>]					+					+	
<i>Gafrarium</i> sp.										+	
<i>Gomphina</i> sp.										+	
<i>Irus irus</i> (Linnaeus, 1758) [= <i>Venus macrophylla</i>]					+						
<i>Irus</i> sp.										+	
<i>Meretrix meretrix</i> (Linnaeus, 1758)										+	
<i>Periglypta reticulata</i> (Linnaeus, 1758) [= <i>Venus reticulata</i>]					+						
<i>Pitar sulfureus</i> Pilsbry, 1904					+						
<i>Placamen isabellina</i> (Philippi, 1849) [= <i>Chione isabellina</i> , <i>Clausinella isabellina</i>]										+	
<i>Ruditapes philippinarum</i> (Adams et Reeve, 1850) [= <i>Tapes philippinarum</i> , <i>Venerupis philippinarum</i>]					+					+	
<i>Tapes belcheri</i> Sowerby II, 1852					+						
<i>Tapes literatus</i> (Linnaeus, 1758)										+	
<i>Tapes</i> sp.					+						
<i>Venerupis variegata</i> (Sowerby II, 1852) [= <i>Tapes variegata</i>]					+					+	
<i>Venerupis</i> sp.					+						
<i>Venus cassinaeformis</i> (Yokoyama, 1926) [= <i>V. foveolata</i>]					+						
<i>Venus</i> sp.					+						
Family Trapezidae											
<i>Coralliophaga</i> spp.					+		+				
<i>Neotrapezium sublaevigatum</i> (Lamarck, 1819) [= <i>Trapezium sublaevigatum</i>]										+	
<i>Trapezium bicarinatum</i> (Schumacher, 1817)										+	
<i>Trapezium oblongum</i> (Linnaeus, 1758)					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Glauconomidae											
<i>Glauconome cerea</i> Reeve, 1844 [= <i>Glaucomya cerea</i>]											+
Family Tellinidae											
<i>Loxoglypta transculpta</i> (Sowerby III, 1915) [as <i>Jactellina transculpta</i>]					+						
<i>Macoma</i> sp.											+
<i>Tellina carnicolor</i> Hanley, 1846 [= <i>Clathrotellina carnicolor</i>]					+						
<i>Tellina clathrata</i> Deshayes, 1835 [= <i>Jactellina clathrata</i>]					+						
<i>Tellina diaphana</i> (Deshayes, 1854)											+
<i>Tellina palatum</i> Iredale, 1929 [= <i>Quidnipagus palatum</i>]					+						
<i>Tellina remies</i> Linnaeus, 1758 [= <i>Cyclotellina remies</i>]					+						
<i>Tellina staurella</i> Lamarck, 1818					+						
Family Donacidae											
<i>Donax faba</i> Gmelin, 1791											+
<i>Donax</i> sp.											+
Family Psammobiidae											
<i>Asaphis violascens</i> (Forsskål, 1775) [= <i>A. dichotoma</i>]					+						
<i>Gari elongata</i> (Lamarck, 1818) [= <i>Psammotaea elongata</i>]					+						
Family Semelidae											
<i>Semele cordiformis</i> (Holten, 1802) [as <i>S. sinensis</i>]											+
<i>Semele zebuensis</i> (Hanley, 1844)					+						
Family Cardiidae											
<i>Fragum fragum</i> (Linnaeus, 1758) [= <i>Cardium fragum</i>]					+						
<i>Vasticardium elongatum enode</i> (Sowerby II, 1840) [= <i>V. enode</i>]					+						
<i>Vepricardium</i> sp.					+						
Family Tridacnidae											
* <i>Tridacna crocea</i> Lamarck, 1819					+						
<i>Tridacna maxima</i> (Röding, 1798) [= <i>T. elongata</i>]					+						
<i>Tridacna squamosa</i> Lamarck, 1819					+						
<i>Tridacna</i> sp.				+							
Family Ungulinidae											
<i>Cycladicama cumingii</i> (Hanley, 1846)					+						
Family Mactridae											
<i>Mactra</i> sp.											+
Family Chamidae											
<i>Chama brassica</i> Reeve, 1847					+						
<i>Chama croceata</i> Lamarck, 1819 [= <i>Ch. imbricata</i>]					+						
<i>Chama dunkeri</i> Lischke, 1870					+						
<i>Chama macerophylla</i> Gmelin, 1791 [= <i>Ch. lazarus</i>]					+						
<i>Chama pacifica</i> Broderip, 1835 [as <i>Ch. reflexa</i>]					+						
<i>Chama</i> sp.					+						
Family Galeommatidae											
<i>Scintilla philippinensis</i> Deshayes, 1856 [= <i>S. reevei</i>]					+						
Family Lasaeidae											
<i>Kellia</i> sp.											+
<i>Lasaea undulata</i> (Gould, 1861)				+							

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Mesodesmatidae											
<i>Atactodea striata</i> (Gmelin, 1791)					+						
[= <i>A. glabrata</i> , <i>Mesodesma glabrata</i>]											
<i>Mesodesma</i> sp. [as <i>M. radiata</i>]					+						
Order CARDITIDA											
Family Carditidae											
<i>Cardita variegata</i> Bruguière, 1792					+						
<i>Cardites crassicosatus</i> (Sowerby I, 1825) [= <i>Cardita cuvieri</i>]					+						
Order LUCINIDA											
Family Lucinidae											
<i>Codakia punctata</i> (Linnaeus, 1758) [= <i>Lucina punctata</i>]					+						
<i>Codakia</i> spp.					+					+	
<i>Ctena delicatula</i> (Pilsbry, 1904)					+						
<i>Fimbria soverbii</i> (Reeve, 1842) [= <i>Corbis elegans</i>]					+						
<i>Gonimyrtea</i> sp. [as <i>G. sajoae</i>]					+						
<i>Pegophysema bialata</i> (Pilsbry, 1895)					+						
[as <i>Anodontia stearnsiana</i>]											
Order MYIDA											
Family Corbulidae											
<i>Anisocorbula</i> sp.					+						
<i>Corbula ovalina</i> Lamarck, 1818 [= <i>Aloidis crassa</i>]					+					+	
<i>Corbula</i> spp.					+					+	
Family Pholadidae											
<i>Martesia striata</i> (Linnaeus, 1758)					+						
<i>Jouannetia cumingii</i> (Sowerby II, 1849)					+						
<i>Parapholas quadrizonata</i> (Spengler, 1792)					+						
[= <i>Pholas quadrizonalis</i>]											
Family Teredinidae											
<i>Dicyathifer mannii</i> (Wright, 1866)										+	
<i>Teredo</i> sp.					+						
Order PHOLADOMYIDA											
Family Laternulidae											
<i>Laternula anatina</i> (Linnaeus, 1758)										+	
Order uncertain											
Family Solenidae											
<i>Solen</i> sp.										+	
Family Gastrochaenidae											
<i>Gastrochaena cuneiformis</i> Spengler, 1783 [= <i>G. gigantea</i>]					+						
<i>Gastrochaena</i> sp.					+						
<i>Rocellaria</i> sp. [as <i>R. cuneiformis</i>]					+						
Mollusca incertae sedis											
<i>Lemintina</i> sp.					+						
Phylum BRYOZOA											
Class GYMNOLAEMATA											
Order CTENOSTOMATIDA											
Family Arachnidiidae											
<i>Arachnoidea</i> sp.										+	

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Order CHEILOSTOMATIDA											
Family Bugulidae											
<i>Bugula neritina</i> (Linnaeus, 1758)					+						
<i>Bugulina ditrupae</i> (Busk, 1858) [= <i>Bugula ditrupae</i>]					+						
Family Phidoloporidae											
<i>Reteporella</i> sp. [= <i>Retepora</i> sp.]					+						
Family Schizoporellidae											
<i>Schizoporella serialis</i> (Heller, 1867) [= <i>S. violacea</i>]					+						
Family Membraniporidae											
<i>Jellyella tuberculata</i> (Bosc, 1802) [= <i>Membranipora tuberculata</i>]					+						
Phylum BRACHIOPODA											
Class LINGULATA											
Order LINGULIDA											
Family Lingulidae											
<i>Lingula anatina</i> Lamarck, 1801					+					+	
<i>Lingula</i> sp. [as <i>Lingula unguis</i>]					+						
Phylum ECHINODERMATA											
Class HOLOTHUROIDEA											
Order ASPIDOCHIROTIDA											
Family Holothuriidae											
<i>Actinopyga echinites</i> (Jaeger, 1833)					+						
<i>Actinopyga mauritiana</i> (Quoy et Gaimard, 1834)					+						
<i>Bobadschia vitiensis</i> (Semper, 1868) [= <i>B. tenuissima</i>]					+						
* <i>Holothuria</i> (<i>Halodeima</i>) <i>atra</i> Jaeger, 1833	+			+	+	+	+	+			
* <i>Holothuria</i> (<i>Halodeima</i>) <i>edulis</i> Lesson, 1830				+	+						
<i>Holothuria</i> (<i>Lessonothuria</i>) <i>pardalis</i> Selenka, 1867					+						
<i>Holothuria</i> (<i>Mertensiothuria</i>) <i>hilla</i> Lesson, 1830					+		+	+			
<i>Holothuria</i> (<i>Mertensiothuria</i>) <i>leucospilota</i> (Brandt, 1835) [= <i>H. vagabunda</i> , as <i>Halodeima vagabunda</i> , <i>Cucumaria vagabunda</i>]	+				+	+				+	
<i>Holothuria</i> (<i>Metriatyla</i>) <i>scabra</i> Jaeger, 1833					+						
<i>Holothuria</i> (<i>Platyperona</i>) <i>difficilis</i> Semper, 1868								+	+		
<i>Holothuria</i> (<i>Selenkothuria</i>) <i>moebii</i> Ludwig, 1883					+						
<i>Holothuria</i> (<i>Semperothuria</i>) <i>cinerascens</i> (Brandt, 1835) [as <i>Halodeima cinerascens</i>]					+			+			
* <i>Holothuria</i> (<i>Stauropora</i>) <i>pervicax</i> Selenka, 1867 [= <i>H. (Mertensiothuria) pervicax</i>]					+						
<i>Holothuria</i> (<i>Thymiosycia</i>) <i>arenicola</i> Semper, 1868					+						
<i>Holothuria</i> (<i>Thymiosycia</i>) <i>gracilis</i> Semper, 1868					+						
* <i>Holothuria</i> (<i>Thymiosycia</i>) <i>impatiens</i> (Forskål, 1775)					+	+	+	+			
<i>Holothuria</i> spp. [as <i>H. monocaria</i>]					+			+			
Family Stichopodidae											
<i>Stichopus chloronotus</i> Brandt, 1835					+		+				
<i>Stichopus horrens</i> Selenka, 1867 [= <i>S. variegatus</i>]					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Order DENDROCHIROTIDA											
Family Cucumariidae											
<i>Cucumaria frondosa japonica</i> (Semper, 1868) [= <i>C. japonica</i>]											+
Family Sclerodactylidae											
<i>Afrocucumis africana</i> (Semper, 1867)					+						
<i>Ohshimella nhatrangensis</i> Levin et Dao Tan Ho, 1989					+						
Order APODIDA											
Family Chiridotidae											
<i>Chiridota rigida</i> Semper, 1867					+						
<i>Polycheira rufescens</i> (Brandt, 1835)					+					+	
Family Synaptidae											
<i>Anapta</i> sp.					+						
<i>Patinapta</i> sp.					+						
<i>Synapta maculata</i> (Chamisso et Eysenhardt, 1821)					+	+					
<i>Synapta</i> sp.					+						
<i>Synaptula</i> sp.					+						
Class ECHINOIDEA											
Order DIADEMATOIDA											
Family Diadematidae											
* <i>Diadema setosum</i> (Leske, 1778)					+	+	+				+
<i>Echinothrix calamaris</i> (Pallas, 1774)								+			
<i>Echinothrix diadema</i> (Linnaeus, 1758)						+					
<i>Eremopyga debilis</i> Mortensen, 1940					+						
<i>Eremopyga denudata</i> (de Meijere, 1902)					+						
<i>Eremopyga</i> sp.					+						
Order CAMARODONTA											
Family Echinometridae											
<i>Echinometra mathaei</i> (Blainville, 1825)					+					+	
<i>Echinostrephus aciculatus</i> A. Agassiz, 1863 [= <i>E. moralis</i>]							+				
<i>Heterocentrotus mamillatus</i> (Linnaeus, 1758)					+						
Family Toxopneustidae											
<i>Toxopneustes pileolus</i> (Lamarck, 1816)					+	+					
<i>Tripneustes gratilla</i> (Linnaeus, 1758)					+						
<i>Tripneustes ventricosus</i> (Lamarck, 1816)						+					
Family Temnopleuridae											
<i>Mespilia globulus</i> (Linnaeus, 1758)					+						
<i>Salmacis sphaeroides</i> (Linnaeus, 1758)					+						
<i>Temnopleurus toreumaticus</i> (Leske, 1778)										+	
Order CIDAROIDA											
Family Cidaridae											
<i>Prionocidaris baculosa</i> (Lamarck, 1816)					+						
Order CLYPEASTEROIDA											
Family Laganidae											
<i>Laganum</i> spp.					+					+	
Order SPATANGOIDA											
Family Loveniidae											
Loveniidae gen. sp.					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Class ASTEROIDEA											
Order PAXILLOSIDA											
Family Astropectinidae											
* <i>Astropecten monacanthus</i> Sladen, 1883			+								
<i>Astropecten scoparius</i> Müller et Troschel, 1842										+	
Order VALVATIDA											
Family Asterinidae											
<i>Aquilonastra batheri</i> (Goto, 1914) [= <i>Asterina batheri</i>]					+						
Family Archasteridae											
<i>Archaster typicus</i> Müller et Troschel, 1840					+					+	
Family Goniasteridae											
<i>Ceramaster japonicus</i> (Sladen, 1889) [= <i>Pentagonaster japonica</i>]					+						
<i>Fromia milleporella</i> (Lamarck, 1816)					+						
<i>Fromia monilis</i> (Perrier, 1869)					+						
Family Ophidiasteridae											
<i>Leiaster leachi</i> (Gray, 1840) [= <i>L. brevispinus</i>]					+						
<i>Linckia laevigata</i> (Linnaeus, 1758)					+		+	+			
<i>Linckia multifora</i> (Lamarck, 1816)					+						
<i>Nardoa frianti</i> Koehler, 1910					+						
<i>Nardoa tuberculata</i> Gray, 1840					+						
Family Oreasteridae											
<i>Choriaster granulatus</i> Lütken, 1869					+						
<i>Protoreaster nodosus</i> (Linnaeus, 1758) [= <i>Oreaster modestus</i>]					+						
Family Solasteridae											
<i>Solaster</i> sp.					+						
Order SPINULOSIDA											
Family Echinasteridae											
<i>Echinaster luzonicus</i> (Gray, 1840)					+						
<i>Echinaster</i> sp.								+			
Class OPHIUROIDEA											
Order OPHIURIDA											
Family Ophiactidae											
<i>Ophiactis savignyi</i> (Müller et Troschel, 1842)			+		+	+		+			
Family Ophiocomidae											
<i>Ophiarthrum elegans</i> Peters, 1851					+						
<i>Ophiocoma</i> (<i>Breviturma</i>) <i>brevipes</i> Peters, 1851 [as <i>Ophiocoma breviceps</i>]					+	+					
<i>Ophiocoma</i> (<i>Breviturma</i>) <i>dentata</i> Müller et Troschel, 1842 [= <i>O. dentata</i>]					+	+					
<i>Ophiocoma erinaceus</i> Müller et Troschel, 1842				+	+						
<i>Ophiocoma pica</i> Müller et Troschel, 1842 [= <i>O. lineolata</i>]					+						
<i>Ophiocoma scolopendrina</i> (Lamarck, 1816)					+	+					
<i>Ophiomastix annulosa</i> (Lamarck, 1816)					+						
<i>Ophiomastix asperula</i> Lütken, 1869					+						
<i>Ophiomastix caryophyllata</i> Lütken, 1869					+						
Family Ophiomyxidae											
<i>Ophiobyrsa intorta</i> (Koehler, 1922) [= <i>Ophiobyrsella intorta</i>]					+						

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Amphiuroidae											
<i>Amphipholis squamata</i> (Delle Chiaie, 1828)				+							
Family Ophiopodidae											
<i>Ophiopis cincta cincta</i> Müller et Troschel, 1842					+						
<i>Ophiopis superba</i> H.L. Clark, 1915					+						
Class CRINOIDEA											
Order COMATULIDA											
Family Comatulidae											
<i>Anneissia bennetti</i> (Müller, 1841) [= <i>Comanthus bennetti</i>]					+						
<i>Capillaster asterias</i> A.H. Clark, 1931					+						
<i>Comanthus parvicirrus</i> (Müller, 1841) [= <i>C. parvicirra</i>]					+						
<i>Comatella stelligera</i> (Carpenter, 1888)					+						
<i>Comatula</i> cf. <i>solaris</i> Lamark, 1816										+	
Family Zygometridae											
<i>Zygometa comata</i> A.H. Clark, 1911					+						
Phylum CHORDATA											
Class ASCIDIACEAE											
Order PHLEBOBRANCHIA											
Family Ascidiidae											
<i>Ascidia sydneyensis</i> Stimpson, 1855					+						
Order APLOUSOBRANCHIA											
Family Polycitoridae											
<i>Eudistoma angolanum</i> (Michaelsen, 1915)					+						
<i>Eudistoma laysani</i> (Sluiter, 1900)					+						
Family Polyclinidae											
<i>Polyclinum vasculosum</i> Pizon, 1908					+						
Order STOLIDOBRANCHIA											
Family Pyuridae											
<i>Herdmania momus</i> (Savigny, 1816)					+						
Family Styelidae											
<i>Eusynstyela latericius</i> (Sluiter, 1904) [= <i>Polyandrocarpa latericius</i>]					+						
Class ACTINOPTERYGII											
Order SCORPAENIFORMES											
Family Scorpaenidae											
<i>Pterois volitans</i> (Linnaeus, 1758)					+						
Order PERCIFORMES											
Family Acanthuridae											
<i>Acanthurus lineatus</i> (Linnaeus, 1758)					+						
<i>Acanthurus triostegus</i> (Linnaeus, 1758)					+						
<i>Ctenochaetus strigosus</i> (Bennett, 1828)					+						
<i>Naso annulatus</i> (Quoy et Gaimard, 1825)					+						
Family Gobiidae											
<i>Boleophthalmus</i> sp.										+	
<i>Gobiodon</i> sp.					+						
<i>Istigobius</i> sp.			+								
<i>Periophthalmus modestus</i> Cantor, 1842 [= <i>P. cantonensis</i>]					+						
Gobiidae gen. sp.					+					+	

Continued

Taxa	Location										
	1	2	3	4	5	6	7	8	9	10	11
Family Blenniidae											
<i>Andamia heteroptera</i> (Bleeker, 1857)					+						
<i>Entomacrodus striatus</i> (Valenciennes, 1836)					+						
[= <i>Salarias fraenatus</i>]											
<i>Salarias</i> sp.					+						
Blenniidae gen. sp.								+			
Family Chaetodontidae											
<i>Chaetodon trifasciatus</i> Park, 1797					+						
Family Scaridae											
<i>Chlorurus japanensis</i> (Bloch, 1789) [= <i>Callyodon blochi</i>]					+						
<i>Scarus niger</i> Forsskål, 1775 [= <i>Callyodon niger</i>]					+						
<i>Scarus scaber</i> Valenciennes, 1840 [= <i>Callyodon scaber</i>]					+						
Family Pomacanthidae											
<i>Chaetodontoplus mesoleucus</i> (Bloch, 1787)					+						
<i>Pomacanthus semicirculatus</i> (Cuvier, 1831)					+						
[= <i>Pomacanthops semicirculatus</i>]											
Family Pomacentridae											
<i>Abudefduf saxatilis</i> (Linnaeus, 1758)					+				+		
<i>Abudefduf sexfasciatus</i> (Lacepède, 1801)					+						
<i>Amblyglyphidodon curacao</i> (Bloch, 1787) [= <i>Abudefduf curacao</i>]				+		+					
<i>Amphiprion percula</i> (Lacepède, 1802)					+						
<i>Dascyllus</i> spp.				+		+					
<i>Pomacentrus</i> spp.				+		+					
Family Haemulidae											
<i>Pomadasys</i> sp.										+	
Family Labridae											
<i>Gomphosus varius</i> Lacepède, 1801					+						
<i>Hemigymnus fasciatus</i> (Bloch, 1792)					+						
<i>Hemigymnus melapterus</i> (Bloch, 1791)					+						
<i>Labroides dimidiatus</i> (Valenciennes, 1839)								+	+		
<i>Thalassoma lunare</i> (Linnaeus, 1758)					+						
Family Siganidae											
<i>Siganus fuscescens</i> (Houttuyn, 1782)										+	
Family Zanclidae											
<i>Zanclus cornutus</i> (Linnaeus, 1758)					+						
Family Terapontidae											
<i>Terapon jarbua</i> (Forsskål, 1775) [= <i>Therapon jarbua</i>]				+		+					
Order TETRAODONTIFORMES											
Family Tetraodontidae											
<i>Arothron stellatus</i> (Anonymous, 1798) [= <i>Tetraodon aerostaticus</i>]										+	
Order ANGUILLIFORMES											
Family Muraenidae											
<i>Echidna nebulosa</i> (Ahl, 1789)					+						
<i>Gymnothorax pictus</i> (Ahl, 1789) [= <i>Muraena picta</i>]					+						
Actinopterygii incertae sedis											
Species 1 [as <i>Doganus fascifassis</i>]										+	
Species 2 [as <i>Scorpenocarpis</i> sp.]										+	

Nemerteans of the coastal waters of Vietnam

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Abstract: Some 260 specimens belonging to 81 nemertean species were collected during Russian–Vietnamese expeditions along the coast of Vietnam. Twelve species are new for Vietnam, including two species (*Parahubrechtia kvisti* sp. nov. and *Tetrastemma albomaculatum* sp. nov.) new for science. *Notospermus albobittatus* (Stimpson, 1855) comb. n. is restored as a valid species. Additional data on the internal morphology of some species are given.

Key words: Nemertea, Vietnam, *Parahubrechtia*, *Tetrastemma*, cLSM.

Nemertea is a phylum of lophotrochozoan invertebrates commonly known as ribbon worms, which includes about 1300 described species (Kajihara et al., 2008). These worms inhabit different types of sea bottom substrates, including silt, sand, algae, sea-grasses and dead corals, and are distributed vertically from the supralittoral to the abyssal zone. About 350 species of nemerteans are now known from the seas of northeast and southeast Asia (Crandall et al., 2002; Kajihara, 2007; Chernyshev, 2013, 2014). However, the nemertean fauna of this region has been investigated rather irregularly, with almost no information on the nemerteans published on the coastal waters of Vietnam. Joubin (1903) described *Cerebratulus velatus* from the Gulf of Tonkin (northern Vietnam), but the generic position of this heteronemertean is remains unclear. Dawydoff (1940) described 20 different nemertean larvae (pilidiae) in Nha Trang Bay (southern Vietnam), and although adult worms were not identified, the variety of larvae definitely indicates high diversity of pilidiophoran nemerteans. He also listed two heteronemerteans, *Baseodiscus unistriatus* (Isler, 1900) and *B. hemprichii* (Ehrenberg, 1831), for Nha Trang Bay (Dawydoff, 1952).

During Russian–Vietnamese expeditions conducted in 2005, 2007 and 2010 along the coast of Vietnam, I collected about 260 specimens corresponding to 81 nemertean species (see Table). Most of these species appear to be undescribed, with the only new species, *Ototyphlonemertes ani* Chernyshev, 2007 described earlier (Chernyshev, 2007). Preliminary data on the nemerteans of Vietnam have been

List of the nemertean species of coastal waters of Vietnam

Taxa/Species	Location												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Class PALAEONEMERTEA													
Order TUBULANIFORMES													
Family Tubulanidae s.l.													
<i>Parahubrechtia kvisti</i> sp. n.				+									
Tubulanidae gen. sp.		+											
Family Cephalotrichidae													
<i>Cephalothrix suni</i> in lit.			+	+									
<i>Cephalothrix</i> cf. <i>fasciculus</i>					+								
Family Cephalotrichellidae													
<i>Cephalotrichella alba</i>					+	+							
<i>Balionemertes</i> sp.			+										
Class NEONEMERTEA													
Order HETERONEMERTEA													
Family Baseodiscidae													
<i>Baseodiscus hemprichii</i>		+	*					+					
<i>Baseodiscus jonassii</i>						+							
<i>Baseodiscus</i> cf. <i>delineatus</i>					+	+			+				
<i>Baseodiscus</i> sp.													+
Family Valenciniidae													
Oxyplellinae gen. sp.			+					+	+				
Family Lineidae													
<i>Lineus binigrilinearis</i>		+	+	+									+
<i>Lineus fuscoviridis</i>													+
<i>Lineus</i> cf. <i>caputornatus</i>		+						+	+		+		
<i>Micrura callima</i>			+	+		+			+	+	+		
<i>Micrura</i> cf. <i>aurantiaca</i>					+								
<i>Micrura</i> sp. 1						+							
<i>Micrura</i> sp. 2					+								
<i>Micrura</i> sp. 3					+								
<i>Dushia</i> sp.		+	+							+			
<i>Notospermus tricuspidatus</i>						+		+					
<i>Notospermus geniculatus</i>													+
<i>Notospermus albovittatus</i>							+					+	
<i>Notospermus</i> sp.			+	+		+					+		
<i>Evelineus</i> cf. <i>mcintoshii</i>					+								+
<i>Eousia verticivaria</i>			+	+	+								
<i>Lineopselloides</i> cf. <i>albilineus</i>					+		+						
Lineidae gen. sp. 1								+					
Lineidae gen. sp. 2							+	+					

Table (Continued)

Taxa/Species	Location												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Lineidae gen. sp. 3									+				
Lineidae gen. sp. 4									+				
Lineidae gen. sp. 5									+				
Lineidae gen. sp. 6												+	
Lineidae gen. sp. 7													+
Superorder HOPLONEMERTEA													
Order POLYSTYLIFERA													
Suborder REPTANTIA													
Drepanophoridae gen. sp. 1			+					+					
Drepanophoridae gen. sp. 2										+			
Drepanophoridae gen. sp. 3						+							
Drepanophoridae gen. sp. 4			+										
Eureptantia gen. sp. 1												+	
Eureptantia gen. sp. 2						+							
Eureptantia gen. sp. 3									+				
Order MONOSTYLIFERA													
Suborder CRATENEMERTEA													
Family Cratenemertidae													
Cratenemertidae gen. sp. 1								+					
Cratenemertidae gen. sp. 2													+
<i>Nipponnemertes</i> sp.						+							
Suborder EUMONOSTILIFERA													
Family Ototyphlonemertidae													
<i>Ototyphlonemertes ani</i>			+										
<i>Ototyphlonemertes</i> cf. <i>martynovi</i>			+										
Family Poseidonemertidae													
<i>Diplomma serpentina</i>	+		+	+	+	+			+		+		
Family Tetrastemmatidae													
<i>Tetrastemma</i> ex gr. <i>roseocephalum</i>	+												
<i>Tetrastemma albomaculatum</i> sp. n.						+			+				
<i>Tetrastemma</i> sp. 1								+			+		
<i>Tetrastemma</i> sp. 2								+	+				
<i>Tetrastemma</i> sp. 3			+						+				
<i>Tetrastemma</i> sp. 4				+		+							
<i>Tetrastemma</i> sp. 5					+								
<i>Tetrastemma</i> sp. 6												+	
<i>Tetrastemma</i> sp. 7												+	
<i>Tetrastemma</i> sp. 8												+	
<i>Tetrastemma</i> sp. 9												+	
<i>Tetrastemma</i> sp. 10			+										

Table (Continued)

Taxa/Species	Location												
	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Tetrastemma</i> sp. 11										+			
<i>Tetrastemma</i> sp. 12										+			
<i>Tetrastemma</i> sp. 13				+									
<i>Tetrastemma</i> sp. 14						+							
<i>Tetrastemma</i> sp. 15					+								
<i>Tetrastemma</i> sp. 16					+								
<i>Tetrastemma</i> sp. 17									+				
<i>Nemertellina</i> sp. 1						?+		+					
<i>Nemertellina</i> sp. 2				+									
Family Oerstediiidae													
Oerstediiidae gen. sp.			+										
Eumonostilifera gen. sp. 1	+												
Eumonostilifera gen. sp. 2	+												
Eumonostilifera gen. sp. 3									+				
Eumonostilifera gen. sp. 4									+				
Eumonostilifera gen. sp. 5												+	
Eumonostilifera gen. sp. 6			+										
Eumonostilifera gen. sp. 7			+										
Eumonostilifera gen. sp. 8													+
Eumonostilifera gen. sp. 9				+									
Eumonostilifera gen. sp. 10				+									
Eumonostilifera gen. sp. 11						+							
Eumonostilifera gen. sp. 12					+								

Notes. Locations: 1 – Tonkin Bay, Dang Khoa Island; 2 – Nha Trang Bay; 3 – Van Phong Bay; 4 – Nam Du Island; 5 – Cu Lao Cham Islands; 6 – Cu Lao Thu Island; 7 – 11°16.5' N, 109°18.3' E, dredge station; 8 – Bach Long Vi Island; 9 – Cu Lao Re Island; 10 – Hon Cau Island; 11 – Tho Chu Island; 12 – Vanguard Bank, dredge station; 13 – Paracel Islands, dredge station.

*Dawydoff (1940).

**Prof. Sun Shichun (personal communication).

published in a brief report (Chernyshev, 2011a). In that paper, a complete faunal list and descriptions of some species, including two new species, were presented (see Table). New data on the internal morphology of some nemertean species have been obtained via utilization of phalloidin labeling in conjunction with confocal laser scanning microscopy (cLSM). The following abbreviations are accepted herein: ICM, inner circular body musculature; OCM, outer circular body musculature; OLM, outer longitudinal body musculature; B, length of the basis; b, width of the basis; S, length of the central stylet.

Material and methods

For morphological study, living specimens were anaesthetized with 7% $MgCl_2$ and fixed with 4% formaldehyde in sea water. Thereafter, the specimens were dehydrated in 100% EtOH, cleared in xylene and embedded in paraffin wax (m.p. 56–57°C). Serial sections 6–8 μm thick were stained according to Mallory's trichrome method (with the addition of chromotrope 2R). For CLSM, pieces of the body and proboscis were stained for 10 h at room temperature with phalloidin-Alexa Fluor 633 (Invitrogen, USA) diluted (1:200) in 1% triton X-100 (Serva, Germany) in phosphate-buffered saline (PBS). The samples were immersed in Mowiol 4-88 (Sigma, USA) and mounted on glass slides. The slides were examined with a LSM-510 Meta and LSM-780 confocal microscopes (Carl Zeiss, Germany). The material was deposited in the Museum of the A.V. Zhirmunsky Institute of Marine Biology FEB RAS, Vladivostok.

Systematic part

Class **PALAEONEMERTEA**

Order **TUBULANIFORMES**

Family **Tubulanidae** s.l.

Genus *Parahubrechtia* Gibson et Sundberg, 1999

Parahubrechtia kvisti sp. nov.

Figs. 1, 2

Parahubrechtia sp.: Kvist et al., 2015, tab. 1, IZ-45554.

Material. Holotype, mature female (transverse sections, MIMB no. 29887), 15th May 2010, South China Sea, Vietnam, Nam Du Island, 09°43' N, 104°23' E, depth 3–5 m, dead corals, coll. A.V. Chernyshev. One more specimen (female) was collected in the same locality.

Description. External features. Living specimens 10–12 mm in length and 0.4–0.6 mm in width; foregut portion rounded in transverse sections, posterior portion cylindrical; living specimens whitish (slightly yellow in intestine region), translucent in cephalic and foregut regions; epidermis becomes milky white about one-third back from anterior end, forming glandular 'ring' typical of tubulanids (not visible in fixed specimens); two oval lateral organs elongated in anterior-posterior direction; head bluntly rounded, with very small rhynchopore and mouth; fixed specimens with transverse ventral furrow just before mouth; eyes absent.

Internal morphology. Epidermis 22–32 μm tall in foregut region, containing red-stained granular cells and cells with filamentous contents (Fig. 2K); dermis very thin. OCM and ICM thin, especially in gut region; ICM merging with rhynchocoel

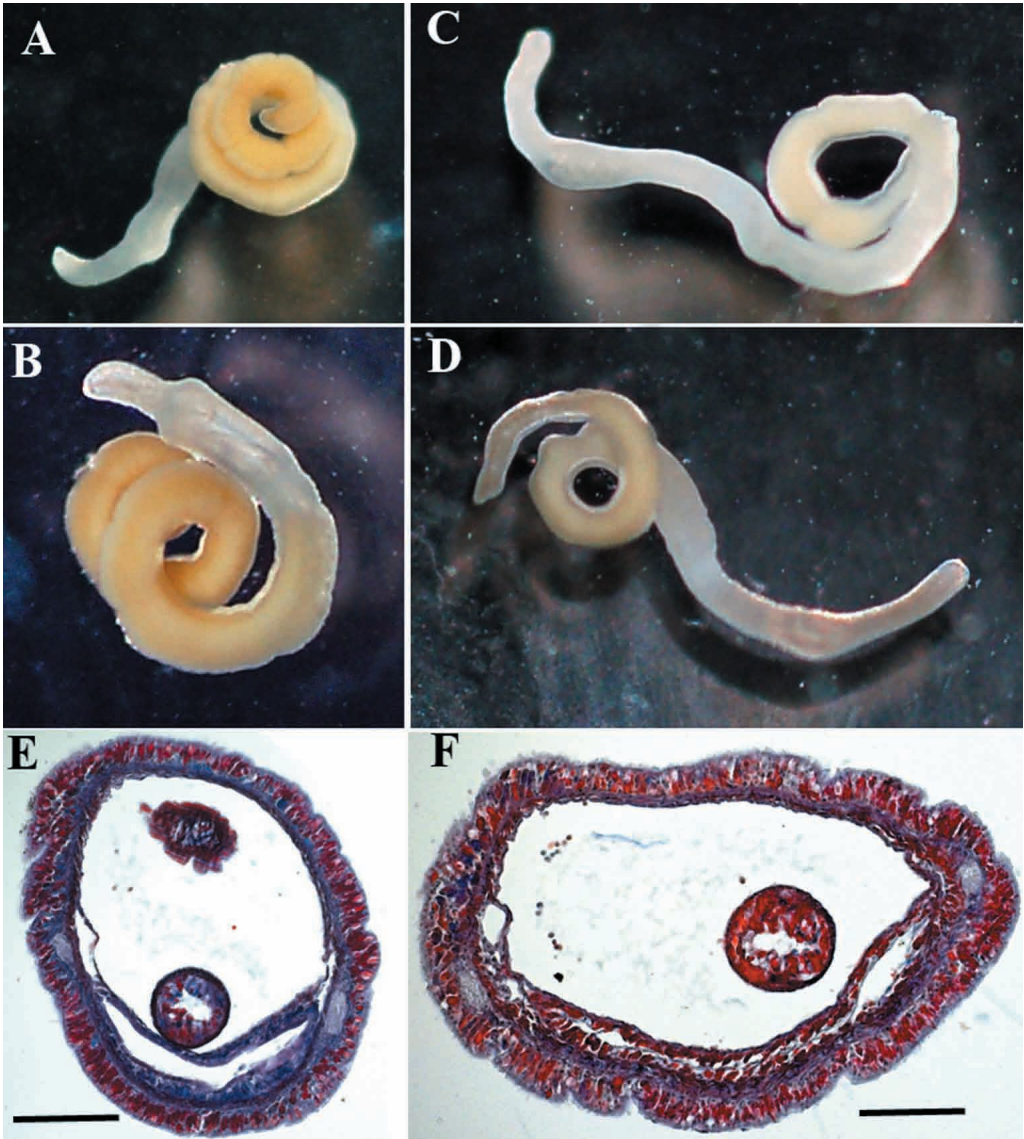


Fig. 1. *Parahubrechtia kvisti* sp. n.: (A, B) living specimen, holotype; (C, D) second living specimen; (E, F) transverse sections in anterior (E) and posterior (F) foregut region. Scale bars 100 μ m.

circular musculature; diagonal musculature between OCM and longitudinal musculature present in anterior body portion (Fig. 2C); longitudinal body musculature 7–10 μ m thick in foregut region; isolated longitudinal muscles between rhynchocoel wall and foregut not forming muscle plate (Fig. 2A, E); muscle crosses between OCM and ICM not found; transverse muscles numerous in precerebral region

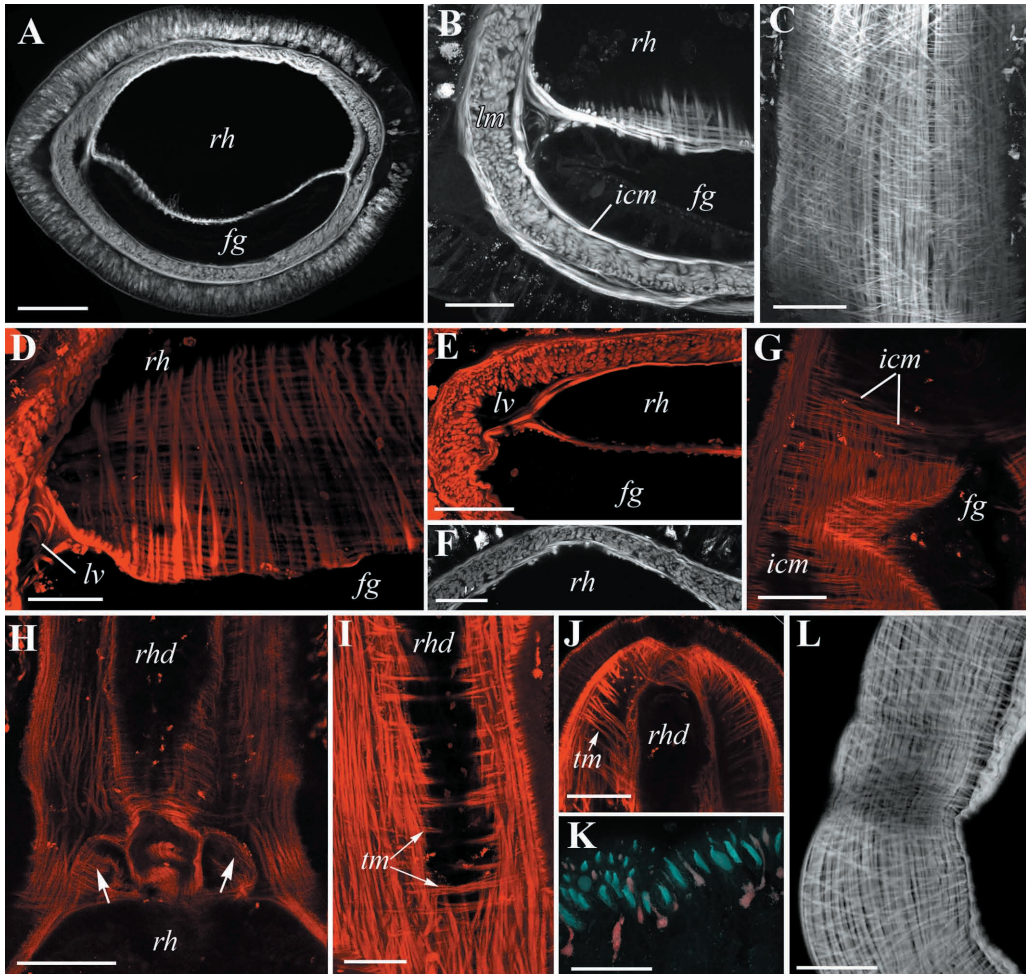


Fig. 2. *Parahubrechtia kvisti* sp. n., cLSM micrographs of the transverse (A, B, D–F) and longitudinal (C, G–L) sections of the body: (A, E) posterior foregut region; (B, D, F) anterior foregut region (D, ventral rhynchocoel wall; F, dorsal rhynchocoel wall); (C, G) body wall musculature of the prece-rebral (C) and anterior foregut region; (H) proboscis insertion (arrows indicate septa); (I) rhyncho-daeum; (J) anterior end; (K) epidermal glands; (E) proboscis. Abbreviations: fg, foregut; icm, inner cir-cular musculature; lm, longitudinal musculature; lv, lateral vessel; rh, rhynchocoel; rhd, rhynchodaeum; tm, transversal muscles. Scale bars: A, C, E, H – 100 μ m, B, D, F–L – 50 μ m.

(Fig. 2I, J); intraganglionic radial muscles in brain not found. Rhynchodaeum epi-thelium 15–20 μ m thick, glandular. Rhynchocoel width about 70% of body width, extending about 60% of body length; rhynchocoel wall consisting of outer cir-cular musculature and scattered inner longitudinal muscles (Fig. 2D, F); muscle sac absent. Proboscis has a uniform structure throughout its length, about 90–100 μ m in diameter, with two small nerves and four muscle layers (inner circular, longitudinal,

diagonal and outer circular), diagonal muscles crisscrossed (Fig. 2L); glandular epithelium having a bilateral pattern; rod-like pseudocnidae 2.2–2.3 μm long, forming small clusters. Proboscis insertion situated between brain lobes and forming a short septum consisting of circular and radial muscles (Fig. 2H). Blood system simple, consisting of two lateral precerebral lacunae and two lateral postcerebral vessels, walls of vessels with circular (spiral?) muscles; lateral vessels running internal to ICM in anterior foregut region, while in nephridial region situated between body longitudinal musculature and ICM. Nephridia wide, situated above lateral blood vessels. Foregut flattened, 232–246 μm wide; intestine without pouches. Lateral nerve cords and brain situated between dermis and OCM; one dorsal nerve present. Cerebral organs not found. Ovaries densely spaced, arranged in a lateral row on either side of body.

E t y m o l o g y. The species is named after Dr. Sebastian Kvist.

S y s t e m a t i c d i s c u s s i o n. The type species of the genus *Parahubrechtia* was described from Hong Kong (Gibson, Sundberg, 1999) and belongs to the family Hubrechtidae, as was indicated earlier by cladistic analysis (Hylbom, Sundberg, 1994). I proposed to transfer *P. jillae* Gibson et Sundberg, 1999 to the order Tubulaniformes (Chernyshev, 2003, 2011b), because this species lacks a mid-dorsal vessel and possesses lateral organs and a glandular ‘ring’. *Parahubrechtia* lacks clear synapomorphies and differs from *Tubulanus* in the absence of the cerebral organs and from *Callinera* in the absence of the muscular sac in the posterior part of the rhynchocoel. The new species was identified as *Parahubrechtia* based on such features as an unpigmented body, the absence of the cerebral organs and rhynchocoel muscular sac, the presence of inner circular musculature in the body wall, the presence of the lateral organs, the cerebral position of the proboscis insertion, a simple blood system without a mid-dorsal vessel, and a uniform structure of the proboscis. The differences between *P. kvisti* and the type species (the presence of inner longitudinal muscles in the rhynchocoel wall, a more voluminous rhynchocoel and a thinner longitudinal muscle layer in the body wall) indicate that it should be placed in a separate species.

Order ARCHINEMERTEA

Family Cephalotrichellidae

Genus *Cephalotrichella* Wijnhoff, 1913

Cephalotrichella alba Gibson et Sundberg, 1992

Fig. 3A, B

Cephalotrichella alba Gibson et Sundberg, 1992, p. 98–105, text-figs. 1, 2, pl. 1, figs. A–H, pl. 2, figs. A–C; Kvist et al., 2015: tab. 1, IZ-45638, fig. 3G.

Cephalothrix alba (Gibson et Sundberg, 1992): Sundberg et al., 2003, p. 292.

Material. 3 specimens, 18th May 2010, Cu Lao Thu Island, 10°32' N, 108°55' E, depth 6–9 m, dead corals; 1 specimen, 26th May 2010, Cu Lao Cham Islands, 15°54' N, 108°32' E, depth 1–2 m, dead corals.

Description. Body 10–15 mm long, head pointed, with lateral row of small epidermal eyes on each side (16–20 eyes in each row); body colour whitish. Internal morphology resembles that described for *C. alba* (Gibson, Sundberg, 1992). Worms can swim with eel-like movements.

Distribution. Hong Kong (Gibson, Sundberg, 1992), Vietnam, ?Australia (Rottneest Island – Sundberg, Gibson, 1995).

Remarks. Analysis of the COI fragments of *C. alba* from Vietnam and GenBank sequences showed that specimens of *C. alba* from Belize and the Pacific coast of Panama (GenBank GI: 676889859, 676889861, 676889863) (Leasi, Norenburg, 2014) belong to another species of *Cephalotrichella*.

Genus *Balionemertes* Sundberg, Gibson et Olsson, 2003

***Balionemertes* sp.**

Fig. 3C, D

Balionemertes sp.: Kvist et al., 2015, tab. 1, IZ-45637, fig. 3C.

Material. 1 specimen, 3rd June 2007, Van Phong Bay, Hon Gom Peninsula, 12°33' N, 109°23' E, intertidal, calcareous red algae; 2 specimens, 21st May 2010, Van Phong Bay, 12°40' N, 109°20' E, intertidal, calcareous red algae.

Remarks. This species differs from similar *B. australiensis* Sundberg, Gibson and Olsson, 2003 in the colour pattern of the head and arrangement of the epidermal eyes. *Balionemertes* sp. has six groups of eyes (two dorsal, two ventral and two lateral).

Family **Cephalotrichidae** (=Cephalothricidae, incorrect name)

Genus *Cephalothrix* Oersted, 1843

***Cephalothrix* cf. *fasciculus* (Iwata, 1952)**

Fig. 3E

Material. 1 specimen, 25th May 2010, Cu Lao Cham Islands, 15°53' N, 108°31' E, depth 1–2 m, dead corals.

Description. Body about 30 mm long, pale yellowish translucent, anterior tip yellowish.

Remarks. A COI BLAST search showed 99% identity of this specimen with *C. fasciculus* sensu Leasi and Norenburg, 2014 from Belize (GenBank KM083814.1) and only 93% identity with *C. fasciculus* from Japan (GenBank CU726623.1).

Cephalothrix suni in lit.

Fig. 3F

Cephalothrix sp. VIE: Chen et al., 2010, tab. 2, N 21.

Material. 1 specimen, 13th January 2005, Van Phong Bay, 12°34' N, 109°24' E, intertidal, calcareous red algae; 3 specimens, 18th January 2005, Van Phong Bay, 12°33' N, 109°23' E, intertidal, calcareous red algae; 1 specimen, 15th May 2010, South China Sea, Vietnam, Nam Du Island, 09°43' N, 104°23' E, intertidal, calcareous red algae.

Remarks. It is the second species of *Cephalothrix* with a colour pattern consisting of transverse brown bands. It differs from *C. queenslandica* Sundberg, Gibson et Olsson, 2003 in the orange tip of the head and the position of brown bands on the ventral surfaces only.

Order **HETERONEMERTEA**

Family **Valenciniidae**

Subfamily **Oxypolellinae**

Oxypolellinae gen. sp.

Fig. 3G

Material. 2 specimens, 19th May 2007, Bach Long Vi Island, 20°09' N, 107°44' E, depth 5–7 m, dead corals; 1 specimen, 23rd May 2007, Cu Lao Re Island, 15°23' N, 109°05' E, depth 2–4 m, dead corals; 1 specimen, 22nd May 2010, Van Phong Bay, 12°40' N, 109°20' E, intertidal, calcareous red algae.

Description. Body very soft, 2–4 cm long, dorsal side yellow or lemon yellow, ventral one pale yellowish; head narrow and long, with two short transverse furrows in front of mouth; eyes and caudal cirrus absent. Proboscis with two regions, one region with outer longitudinal musculature, muscle crosses absent. Worms form a mucous cover.

Family **Baseodiscidae**

Genus *Baseodiscus* Diesing, 1850

Baseodiscus hemprichii (Ehrenberg, 1831)

Fig. 3I

Material. 1 specimen, 19th May 2007, Bach Long Vi Island, 20°09' N, 107°44' E, depth 5–7 m, dead corals.

Description. Body about 12 cm long, ground colour pale cream, mid-dorsal longitudinal brown stripe with anterior “collar”, ventral stripe absent, head with dorsal transverse brown patch and numerous eyes; cephalic furrows with secondary grooves.

Distribution. Widely distributed in the tropical zone.

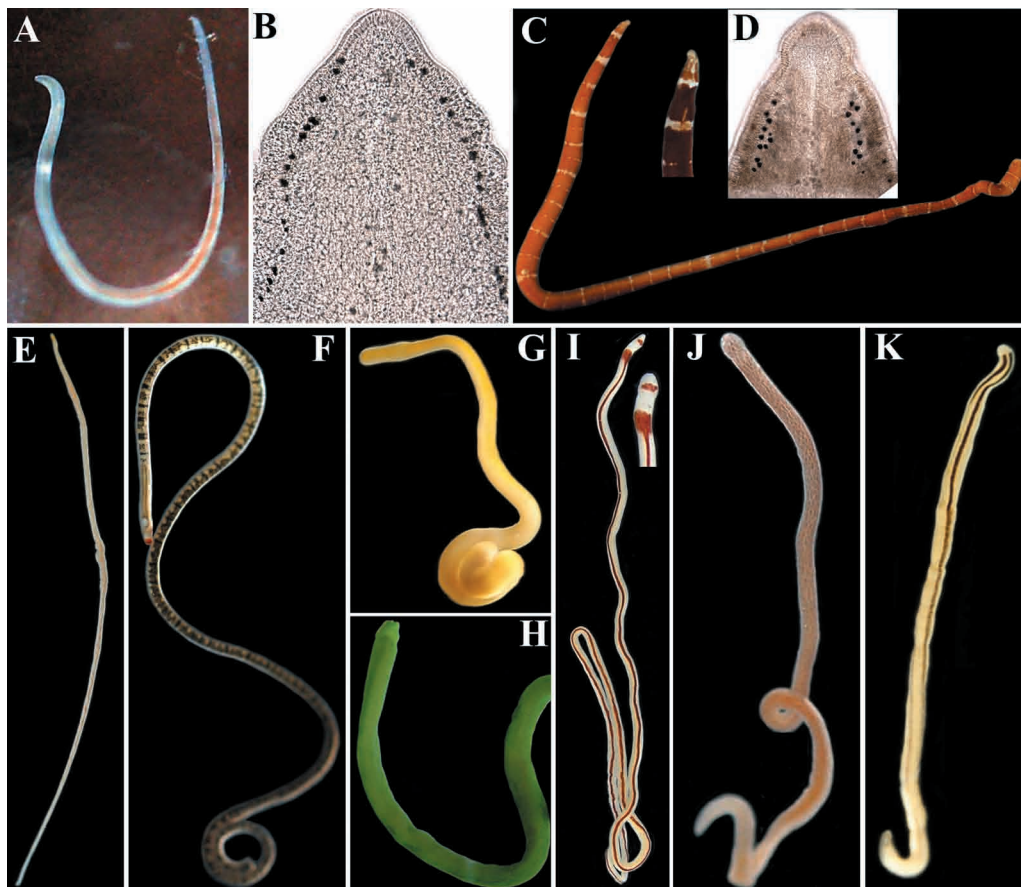


Fig. 3. (A, B) *Cephalotrichella alba*; (C, D) *Balionemertes* sp. (D – ventral side); (E) *Cephalothrix* cf. *fasciculus*; (F) *Cephalothrix suni* in lit.; (G) *Oxypolellinae* gen. sp.; (H) *Lineus fuscoviridis*; (I) *Baseodiscus hemprichii*; (J) *Baseodiscus* cf. *delineatus* (Cu Lao Cham Islands); (K) *Lineus binigrilinearis*.

***Baseodiscus jonasii* Strand, Hjelmgren et Sundberg, 2005**

Fig. 4A

Material. 1 specimen, 18th May 2010, Cu Lao Thu Island, 10°32' N, 108°55' E, depth 6–9 m, dead corals.

Description. Body about 1 m long, ground colour pale yellowish with numerous reddish-brown longitudinal stripes situated irregularly on both dorsal and ventral surfaces; about 80–90 eyes on each side of head; transverse cephalic furrows present, each with 50–60 secondary grooves.

Distribution. Solomon Islands (Strand et al., 2005) and Vietnam.

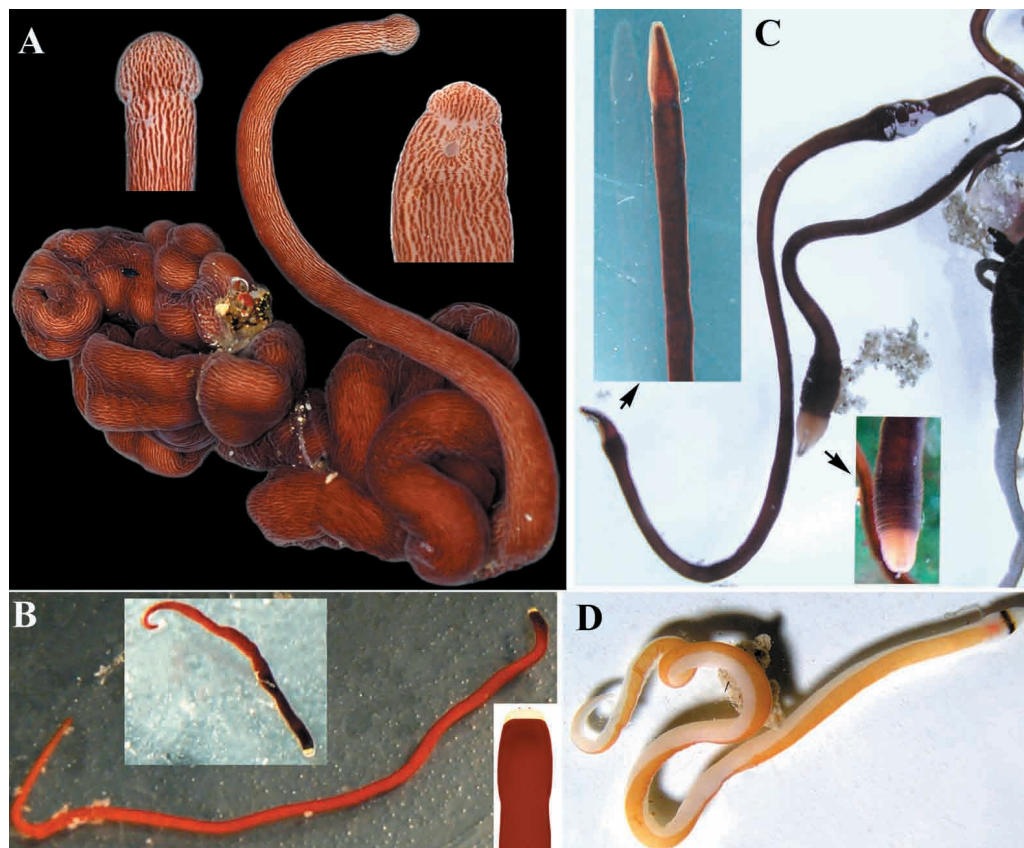


Fig. 4. (A) *Baseodiscus jonasii*; (B) *Lineus* cf. *caputornatus*; (C) *Dushia* sp.; (D) Lineidae gen. sp. 8 (16°05.5' N, 114°55.3' E, depth 287 m).

Baseodiscus* cf. *delineatus (Delle Chiaje, 1825)

Fig. 3J

Material. 1 specimen, 23rd May 2007, Cu Lao Re Island, 15°23' N, 109°05' E, depth 2–4 m, dead corals; 1 specimen; 19th May 2010, Cu Lao Thu Island, 10°31' N, 108°55' E, depth 6–8 m, dead corals; 1 specimen, 26th May 2010, Cu Lao Cham Islands, 15°53' N, 108°31' E, depth 5–10 m, dead corals.

Description. Body about 5–30 cm long, ground colour pale yellowish with numerous pale brownish patches or irregular stripes on dorsal surface; eyes numerous; cephalic furrows with secondary grooves.

Remarks. DNA data (fragment of the gene 16S) indicate that these specimens do not belong to real *B. delineatus* (Dr. H. Kajihara, personal communication).

Family **Lineidae**Genus ***Lineus*** Sowerby, 1806***Lineus binigrilinearis*** Gibson, 1990

Figs. 3K; 6A, B

Material. 1 specimen, 15th January 2005, Nha Trang Bay, Hon Mieu Island, intertidal, *Halimeda* spp.; 1 specimen, Paracel Islands, 16°05.1' N, 114°53.6' E, depth 35–50 m, dead corals; 1 specimen, 3rd June 2007, Van Phong Bay, Hon Gom Peninsula, 12°33' N, 109°23' E, intertidal, calcareous red algae; 2 specimens, 15th May 2010, South China Sea, Vietnam, Nam Du Island, 09°43' N, 104°23' E, depth of 1–3 m, dead corals; 1 specimen, 22nd May 2010, Van Phong Bay, 12°40' N, 109°20' E, intertidal, calcareous red algae.

Description. External features. Body very slender, 20–45 mm long, ground colour pale yellowish or pale cream, head with dorsal semicircular white patch from posterior margin of which two slender longitudinal stripes extend along dorso-lateral body margins; these stripes black, black-brown, pale brown or brick brownish in anterior 1/5–1/3 of body length, fade posteriorly until fragmentating or disappearing; in one specimen two small reddish patches (eyes?) evident on undersurface of head near anterior margin of white patch.

Internal morphology. Proboscis about 0.1 mm in diameter, musculature consisting of inner circular, longitudinal, diagonal and outer circular muscles, muscle crosses absent. Cutis musculature consisting of circular, diagonal and longitudinal (precerebral) or diagonal and longitudinal (just behind mouth) muscles. Brain with numerous intraganglionic radial muscles (Fig. 6A). Well-developed interwoven somatic musculature (without longitudinal muscles) under ventral foregut epithelium (Fig. 6B).

Distribution. Hong Kong (Gibson, 1990) and Vietnam.

Lineus fuscoviridis Takakura, 1898

Fig. 3H

Material. 1 specimen, Paracel Islands, 16°05.1' N, 114°53.6' E, depth 35–50 m, dead corals.

Description. Body length 17 cm (posterior part lost), green; head truncated, with colourless margins and numerous small eyes; lateral cephalic furrows very deep, often wide open, brain evident as reddish patch in cephalic furrows.

Distribution. Japan (Prefectures Kanagawa, Chiba, Kumamoto, Hiroshima, Wakayama, Ehime and Niigata), South Korea, Paracel Islands.

Lineus cf. caputornatus Takakura, 1898

Fig. 4B

Material. 2 specimens, 15th January 2005, Nha Trang Bay, Hon Mieu Island, intertidal, calcareous red algae; 3 specimens, 19th May 2007, Bach Long Vi Island, 20°09' N, 107°44' E, depth 5–7 m, dead corals; 1 specimen, 23rd May 2007, Cu Lao Re Island, 15°23' N, 109°05' E, depth 2–4 m, dead corals; 1 specimen, 13th May 2010, Tho Chu Island, intertidal, calcareous red algae.

Description. Body slender, 9–30 mm long, head bluntly rounded; ground colour brownish red, purple brown or deep cherry on dorsal surface, ventral surface paler; above and below anterior part of head with half-moon white or white-yellow patch; two brownish-red or orange dots (eyes?) close to anterior edge of cephalic patch (largest specimen with a few additional brownish red spots here); caudal cirrus not found.

Remarks. Takakura (1898) described *Lineus caputornatus* from the Kanagawa Prefecture and gave the following description for this species (translated by Dr. Hiroshi Kajihara): “This beautiful species is rarely found in the vicinity of Misaki, about 5 cm in maximum length, 1 mm in width. The body is rather rounded. The head region has the same width in both anterior and posterior portions, not demarcated from the neck, the tip of the head is bluntly rounded, but slightly truncated. The body color is anteriorly blackish brown, posteriorly reddish brown, ventrally paler in both anterior and posterior portions. The dorsal surface of the head is colorless and has a yellow patch. There is a lunular row of reddish brown dots along the anterior edge of the yellow patch. The lateral groove is fairly long, about eight times longer than the head width. Eyes are not found” (p. 334–335).

Our specimens are very similar to *L. caputornatus* but differ in having only two terminal dots. After its original description *L. caputornatus* was not found, and there is no data on the intraspecific variability and internal morphology of this species. Noteworthy, *L. caputornatus* is similar to *Perissonemertes pyrrocephalus* Gibson, 1990 (correct specific name – *pyrrocephala*) and it is not unlikely that both are the same species.

Genus *Dushia* Corrêa, 1963

Dushia sp. (?*Micrura formosana* Yamaoka, 1939)

Fig. 4C

Material. 4 specimens, 10th January 2005, Van Phong Bay, 12°39' N, 109°20' E, intertidal, under stones; 1 specimen, 15th January 2005, Nha Trang Bay, Hon Mieu Island, intertidal, under stone; 2 specimens, 11th May 2010, Hon Cau Island (Con Son Archipelago), intertidal, under stone.

Description. External features. Body 6–16 cm long and 1–2 mm wide, with caudal cirrus; head bluntly pointed, with 3 small tubercles on tip and pair of long lateral cephalic furrows; rhynchopore subterminal, ventral; mouth long, slit-like; general body colour dark brown (small specimens paler), head (including cephalic furrows) with paler margins, brain externally evident as reddish-brown patch; posterior end of body whitish; eyes absent.

Internal morphology. Proboscis typical ‘heterotype’ (i.e. with outer longitudinal musculature), with two muscle crosses; proboscis gland epithelium containing dark pigment, numerous sensory cells and clusters of pseudocnidae. Cutis without connective tissue zone separating glands and OLM, cutis glands not penetrating outer longitudinal musculature. Foregut without subepithelial gland layer. In precerebral region three blood lacunae (two lateral and one dorsal); vascular plexus present in foregut region. Three frontal organs.

Remarks. A COI BLAST search of *Dushia* sp. from Hon Cau Island revealed a top match of *Parvicirrus dubius* (Verrill, 1879) and *Micrura dellechiaiei* (Hubrecht, 1879) (Terra Hiebert, personal communication). Unfortunately, COI sequence of *Dushia atra* (Girard, 1851) (GenBank EF124967.1) is dubious.

Genus *Micrura* Ehrenberg, 1828

Micrura callima Sundberg et Gibson, 1995

Figs. 5A; 6C–E

Material. 5 specimens, 23rd May 2007, Cu Lao Re Island, 15°23' N, 109°05' E, depth 2–4 m, dead corals; 2 specimens, 11th May 2010, Hon Cau Island (Con Son archipelago), depth 3 m, dead corals; 2 specimens, 13rd May 2010, Tho Chu Island, 09°19' N, 103°30' E, depth 3–5 m, dead corals; 2 specimens, 15th May, 2010, Nam Du Island, 09°43' N, 104°23' E, depth 3–5 m, dead corals; 1 specimen, 18th May 2010, Cu Lao Thu Island, 10°32' N, 108°55' E, depth 6–9 m, dead corals; 1 specimen, 21st May 2010, Van Phong Bay, 12°40' N, 109°20' E, depth 1–2 m, dead corals.

Description. External features. Body slender, 5–15 mm long, with long caudal cirrus; ground colour purple brown on dorsal side, head with a whitish patch edged yellowish, body with 10–25 white or yellowish transverse bands and three longitudinal stripes – one mid-dorsal blue or magenta-purple and two submedian orange stripes (one specimen from Van Phong Bay without mid-dorsal stripe); tip of head colourless with two–four small orange eyes.

Internal morphology. Proboscis about 0.15–0.18 mm in diameter, musculature consisting of inner circular, inner longitudinal, diagonal, outer circular and outer longitudinal muscles, one (dorsal) muscular cross present in anteriormost portion

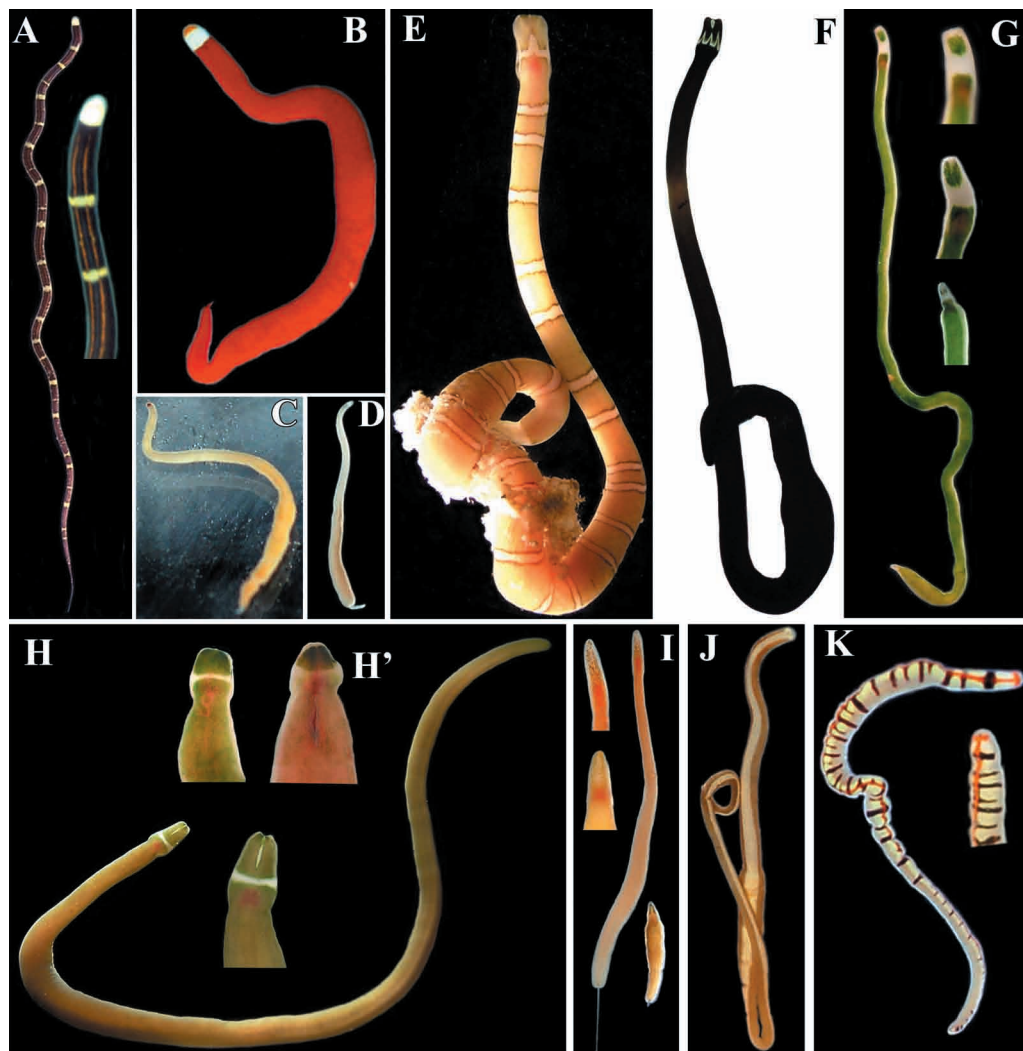


Fig. 5. (A) *Micrura callima*; (B) *Micrura* cf. *aurantiaca*; (C) *Micrura* sp. 2; (D) *Micrura* sp. 3; (E) *Notospermus geniculatus*; (F) *Notospermus tricuspidatus*; (G) *Notospermus* sp.; (H, H') *Notospermus albovittatus* (H – Vanguard Bank; H' – 11°16.5' N, 109°18.3' E); (I) *Eousia verticivaria*; (J) *Lineopselloides* cf. *albilineus* (11°16.5' N, 109°18.3' E, depth 104–107 m); (K) *Evelineus* cf. *mcintoshii*.

of proboscis; proboscis gland epithelium with clusters of pseudocnidae on ventral ridge (Fig. 6C). Brain with numerous intraganglionic radial muscles (Fig. 6D), lateral nerve cords with a few longitudinal myofibrillae (Fig. 6E). Foregut musculature weakly developed, consisting of interwoven muscles.

Distribution. Australia, Japan, Vietnam, Guam (unpublished data).

Micrura cf. aurantiaca (Grube, 1855)

Fig. 5B

Material. 1 specimen, 24th May 2010, Cu Lao Cham Islands, 15°56' N, 108°29' E, depth 5–7 m, dead corals.

Description. Body 30 mm long, with pale reddish caudal cirrus, head bluntly pointed; ground colour red on dorsal side, head with white patch and orange anterior point (both on dorsal and ventral surfaces); two anterior orange eyes.

Remarks. The specimen is very similar to *Micrura* (= *Leucocephalonemertes*) *aurantiaca* (Grube, 1855) from the Europe coast, but genetic comparison showed specimen from Vietnam belongs to separate species.

Micrura sp. 1

Material. 1 specimen, 18th May 2010, Cu Lao Thu Island, 10°32' N, 108°55' E, depth 6–9 m, dead corals.

Description. Body 8 mm long, with a long caudal cirrus; body whitish except orange patch on head; two orange terminal eyes.

Micrura sp. 2

Fig. 5C

Material. 1 specimen, 26th May 2010, Cu Lao Cham Islands, 15°54' N, 108°32' E, depth 1–2 m, dead corals.

Description. Body about 30 mm long, yellowish, with lilac terminal patch on head; caudal cirrus present, eyes absent.

Micrura sp. 3

Fig. 5D

Material. 1 specimen, 24th May 2010, Cu Lao Cham Islands, 15°56' N, 108°29' E, depth 5–7 m, dead corals; 1 specimen, 26th May 2010, Cu Lao Cham Islands, 15°54' N, 108°32' E, depth 1–2 m, dead corals.

Description. Body 7–8 mm long, with long caudal cirrus; body yellowish except white patch on head; eyes absent.

Genus *Notospermus* Henschke, 1829

Notospermus geniculatus (Delle Chiaje, 1828)

Fig. 5E

Material. 1 specimen, Paracel Islands, 16°09.7' N, 114°52.8' E, depth 247 m, dead corals.

Description. Body about 12 cm long. Body colour pattern typical of *N. geniculatus*, but ground colour tan or pale sandy brown. Eyes numerous.

Distribution. Widely distributed in tropical and subtropical zones.

Notospermus tricuspidatus (Quoy et Gaimard, 1833)

Fig. 5F

Material. 1 specimen, 21st May 2007, Bach Long Vi Island, 20°08' N, 107°44' E, depth 3–5 m; 1 specimen, 18th May 2010, Cu Lao Thu Island, 10°32' N, 108°55' E, depth 6–9 m, dead corals.

Description. Body about 12–14 cm long. Body colour pattern typical of *N. tricuspidatus*, ground colour dark brownish-green.

Distribution. Widely distributed in tropical and subtropical zones of the Indian and Pacific oceans.

Notospermus albovittatus (Stimpson, 1855) comb. n.

Figs. 5H, H'; 6F–I

Meckelia albo-vittata Stimpson, 1855, p. 382 (non *Cerebratulus albovittatus* sensu Bürger, 1890, nec *Lineus albovittatus* sensu Iwata, 1954).

Material. 1 specimen, 29th May, 2007, South China Sea, Vanguard Bank, 07°24.6' N, 109°33.4' E, dredge, depth 72–87 m, dead corals; 1 specimen, 22nd May, 2010, South China Sea, 11°16.5' N, 109°18.3' E, dredge, depth 107–104 m, dead corals.

Description. External features. Body 13–20 cm long and 4–5 mm wide, head flattened, truncated, with long lateral cephalic furrows; mouth long and slit-like; caudal cirrus absent. Ground colour brownish green or olive green on dorsal surface, ventral surface paler (greenish red in second specimen), brain externally evident as reddish patch; head (including cephalic furrows) with paler margins and transverse white band on both dorsal and ventral surfaces, specimen (Vanguard Bank) with a narrow longitudinal white patch on dorsal side (Fig. 5H). About 25–35 eyes on each margin of head. Blood red.

Internal morphology. Proboscis with two muscle crosses, outer longitudinal muscle not found. Cutis glands distinguished from OLM; cutis musculature well developed, consisting of outer circular, diagonal and inner longitudinal muscles (Fig. 6G). Radial musculature well developed, intraganglionic radial muscles forming thick fascicles. Foregut somatic musculature well developed, consisting of interwoven longitudinal and diagonal muscles (Fig. 6H, I). Cephalic vessel as simple loop.

Distribution. Japan (Okinawa Prefecture) (Stimpson, 1855) and Vietnam.

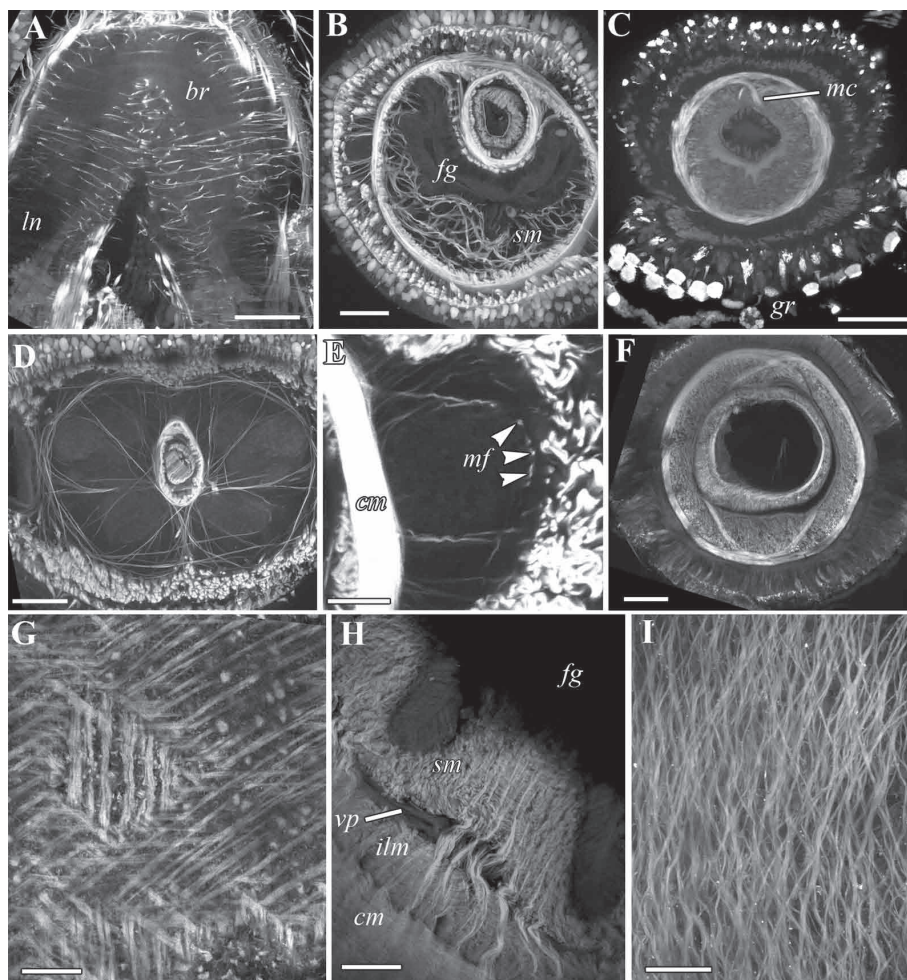


Fig. 6. CLSM micrographs of the longitudinal (A, G, I) and transverse (B–F, H) sections. (A, B) *Lineus binigrilinearis* (A – cerebral region; B – foregut region); (C–E) *Micrura calima* (C – everted proboscis; D – brain; E – lateral nerve cord); (F–I) *Notospermus albovittatus* (F – everted proboscis; G – cutis musculature; H – foregut region; I – foregut somatic musculature). Abbreviations: *br*, brain; *cm*, circular musculature; *fg*, foregut; *gr*, glandular ridge; *ilm*, inner longitudinal musculature; *ln*, longitudinal nerve cord; *mc*, muscle cross; *mf*, myofibrillae; *sm*, foregut somatic musculature; *vp*, vascular plexus. Scale bars: A–D, G, I – 50 μ m, E – 20 μ m, F, H – 100 μ m.

R e m a r k s. Both specimens correspond to the original descriptions of *Meckelia albo-vittata*, except the body ground colour (“grass-green”: Stimpson, 1855, p. 382). Gibson (1981) and Riser (1991) synonymized this species with *N. tricuspidatus*, but both species differ in the shape of the transverse band on the head (W-shaped in *N. tricuspidatus* and straight in *N. albovittatus*).

Notospermus sp.

Fig. 5G

Lineus albovittatus sensu Iwata, 1954, p. 27–29, figs. 1, 2.

Material. 3 specimens, 15th May 2010, South China Sea, Vietnam, Nam Du Island, 09°43' N, 104°23' E, intertidal, calcareous red algae; 6 specimens, 21st and 22nd May 2010, Van Phong Bay, 12°40' N, 109°20' E, intertidal, calcareous red algae; 3 specimens, 13th May 2010, Tho Chu Island, intertidal, calcareous red algae; 1 specimen; 19th May 2010, Cu Lao Thu Island, 10°31' N, 108°55' E, depth 6–8 m, dead corals.

Description. Body slender, tapering posteriorly, 2–5 cm long; head narrow and bluntly pointed, with long lateral cephalic furrows and a short slit-like mouth; caudal cirrus absent. Dorsal surface green, brain externally evident as reddish patch, ventral surface pale greenish; anterior half of head white with a green patch (one specimen with divided in two patches) and a row of 8–11 distinct black eyes on each side; blood red.

Distribution. Japan (Tokara Islands), Vietnam.

Remarks. Our specimens are very similar to *Lineus albovittatus* sensu Iwata (1954) but are distinguished from *N. albovittatus* by the body size and the form of the head. I think that these specimens belong to a new species of the genus *Notospermus*.

Genus *Evelineus* Corrêa, 1954

Evelineus cf. *mcintoshii* (Langerhans, 1880)

Figs. 5K; 7A–C; 12A–C

Lineus Mcintoshii Takakura, 1898, p. 187, fig. 10.

Lineus mcintoshii (Langerhans, 1880) sensu Takakura, 1898: Kajihara, 2007, p. 316.

Material. 2 specimens, 25th May 2010, Cu Lao Cham Islands, 15°53' N, 108°31' E, depth 1–2 m, dead corals.

Description. External features. Body slender, about 20 mm long; head not demarcated from body, bluntly rounded on tip; caudal cirrus absent. Ground colour of dorsal and lateral body surfaces pale yellowish with about 40 transverse black rectangular patches of violet tint interrupted by mid-dorsal thin orange stripe; black patches connected together on either side of orange stripe; anterior tip of head with thin orange transverse straight patch connected with mid-dorsal stripe; ventral surface pale and without any colour pattern. Lateral cephalic furrows reaching to second transverse band. Eyes not found.

Internal morphology. Epidermis containing numerous red-stained gland cells. Cutis extracellular matrix well developed but not forming distinct layer between

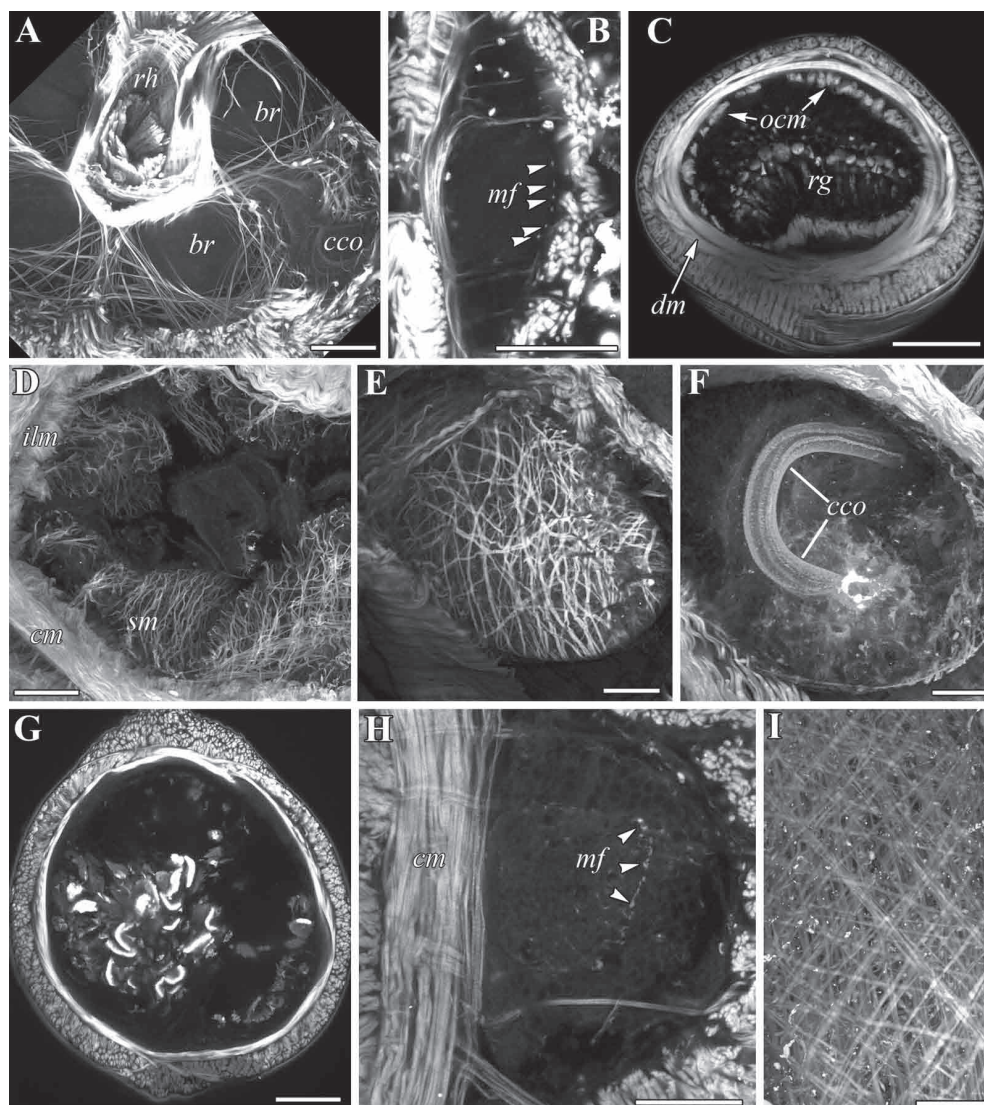


Fig. 7. CLSM micrographs of the transverse (A–H) and longitudinal (I) sections. (A–C) *Evelineus* cf. *mcintoshii* (A – brain; B – lateral nerve cord; C – proboscis); (D–I) *Eousia verticivaria* (D – foregut; E, F – cerebral organ; G – proboscis; H – lateral nerve cord; I – cutis musculature). Abbreviations: *br*, brain; *cco*, canal of cerebral organ; *cm*, circular musculature; *dm*, diagonal musculature; *gr*, glandular ridge; *ilm*, inner longitudinal musculature; *mf*, myofibrillae; *ocm*, outer circular musculature; *rh*, rhynchocoel; *sm*, foregut somatic musculature. Scale bars 50 µm.

cutis glands and OLM; cutis glands not penetrating OLM, cutis (dermal) musculature thin, consisting of outer circular, diagonal and inner longitudinal muscles. Rhynchocoel wall very thin, consisting of outer circular and isolated inner

longitudinal muscles. Proboscis musculature consisting of layers of thin endothelial circular, inner longitudinal, diagonal, outer circular and outer longitudinal muscles; muscle crosses not found; ventral ridge of gland epithelium with numerous round clusters of pseudocnidae (Fig. 7C). Vascular plexus present in foregut region but weakly developed; vascular plug short. Foregut flattened, with thin epithelium and without subepithelial gland cell layer; foregut somatic musculature weakly developed, consisting of interwoven muscles; gut with simple shallow lateral pouches. Brain with an outer and inner neurilemma and without neurochord cells, intraganglionic radial muscles well developed (Fig. 7A); lateral nerve cords arching laterally before continuing posteriorly (Fig. 12B), with a few longitudinal myofibrillae (Fig. 7B). Cerebral organs well developed, fused with posterior part of dorsal brain lobes. Cephalic glands well developed in anterior precerebral region. Three frontal organs.

Distribution. Vietnam, China (Prof. Shichun Sun, personal communication), Japan (Kanagawa Prefecture – Takakura, 1898). According to Mr. Vishal Bhawe (Bombay Natural History Society), this species was found off the coast of Gujarat and Maharashtra (<http://givingmirth.blogspot.ru/2012/10/ribbon-worm.html>).

Remarks. Takakura (1898) described this species as *Lineus Mcdintoshii* (sic!) (Langerhans). He gives the following description for this species (translated by Prof. H. Kajihara): “The body length is about 8 or 9 cm, width 1 mm. A beautiful species, the cephalic tip is bluntly pointed, that of the tail is rather thin, the head is not demarcated from the neck, the dorsal surface assumes a pale yellow color, the cephalic tip and the margins of the dorsal as well as the ventral surface of the body are almost colorless. There is a flattened triangular reddish patch on rather posterior portion of the cephalic tip. From the center of this patch a single red line extends along the dorsal median line to reach to the tip of the tail. On either side of this red line numerous transverse dark brown patches are rather regularly arranged. The distal ends of the patches slightly reach the ventral surface, while the proximal ends are connected with a longitudinal dark brown line, which abuts on each side of the longitudinal red line. The general shape of the patches takes a rather triangle, which is proximally wide and distally narrow. In front of the reddish patch on the tip of the head, there are two small black dots. These dots are sometimes transformed into longitudinal short black lines which extend rather posteriorly. The cephalic grooves are long and reach the second transverse patches. The eyes are absent” (p. 187).

Vietnamese specimens differ little from Takakura’s description (black transverse bands and an orange longitudinal stripe). Our specimens can be distinguished from the type species of the genus *Evelineus*, *E. tigrillus* Corrêa, 1954, from

the coast of Brazil by the form of the black patches (triangular in *E. tigrillus*) and of the orange patch on the head (half-moon in *E. tigrillus*); however, both features are variable in the specimens from China (Prof. Sun Shichun, personal communication) and India. I think that *E. tigrillus* and *L. mcintoshii* sensu Takakura can be synonyms of *Cerebratulus mcintoshii* Langerhans, 1880 from Madeira. The latter species has a semicircular bright red cephalic patch and disconnected triangular black patches (Langerhans, 1880); however, these features can be found in specimens from the Asian coast. The genus *Iwatanemertes* Gibson, 1990 is, without doubt, a junior synonym of *Evelineus*, but I do not agree with Schwartz's opinion (2009) that the descriptions of *Iwatanemertes piperatus* (Stimpson 1855) are externally identical to *Evelineus tigrillus*. Further revision of this species complex requires molecular genetic data.

Genus *Eousia* Gibson, 1990

Eousia verticivaria Gibson, 1990

Figs. 5I; 7E–I

Eousia verticivarius Gibson, 1990: p. 99–108, text-figs. 14, 15, pl. 16, figs. A–G, pl. 17, figs. A–G.

Material. 1 specimen, 3rd June 2007, Van Phong Bay, Hon Gom Peninsula, 12°33' N, 109°23' E, intertidal, calcareous red algae; 1 specimen, 15th May 2010, Nam Du Island, 09°43' N, 104°23' E, intertidal, calcareous red algae; 1 specimen, 26th May 2010, Cu Lao Cham Islands, 15°54' N, 108°32' E, depth 1–2 m, dead corals.

Description. External features. Body 10–25 mm long and 1–1.5 mm wide, flattened in gut region but body margins not sharp; head rounded triangular, with bluntly pointed tip; lateral longitudinal cephalic furrows deep; rounded mouth small; caudal cirrus present. Ground colour pale yellowish, dorsal surface with numerous small pale olive-brown, olive-grey or pale brown speckles, head more speckled than body; brain externally evident as pale rose patch. On each side of head 20–30 small black eyes arranged in one (two in posterior part) row. Occasionally worms can swim as some *Cerebratulus* species.

Internal morphology. Cutis musculature consisting of outer circular, diagonal and inner longitudinal muscles (Fig. 7I); cutis glands sunken between distal muscles of OLM. Proboscis without inner longitudinal musculature and with two unequal crosses (Fig. 7G). Somatic musculature of foregut consisting of interwoven muscles (Fig. 7D). Intraganglionic radial muscles well developed; lateral nerve cords with 20–25 longitudinal myofibrillae between neuropile and cellular parts (Fig. 7H). Large cerebral organs surrounding post-cerebral lacunae; each organ with long curved internal canal (Fig. 7F) and well-developed external muscle network (Fig. 7E).

Distribution. China (Hong Kong – Gibson, 1990) and Vietnam.

Genus *Lineopselloides* Gibson, 1990

Lineopselloides cf. *albilineus* Gibson, 1990

Fig. 5J

Material. 1 specimen (N 1), South China Sea, 11°16.5' N, 109°18.3' E, dredge, depth of 107–104 m; 1 specimen (N 2), 26th May 2010, Cu Lao Cham Islands, 15°54' N, 108°32' E, depth 1–2 m, dead corals. Both specimens are mature.

Description. Body slender, 8 cm long in specimen N 1 and 1 cm long in specimen N 2; head not demarcated from body, with rounded tip; caudal cirrus absent. Colour pattern similar in both specimens: dark tan ground colour with whitish or pale cream mid-dorsal wide longitudinal stripe; in specimen N 1 longitudinal stripe as wide as 1/3 of body diameter, widening on anterior part of head (Fig. 5J); anterior head edge white, with two orange dots (eyes?); in specimen N 2 longitudinal stripe wider (2/3 of body diameter), without anterior widening and orange dots.

Remarks. Both specimens differ from *Lineopselloides albilineus* from Hong Kong (Gibson, 1990) and Japan (Kajihara, Ise, 2008) in a wider mid-dorsal stripe, and in that the cutis glands are more sunken between the muscles of OLM.

Class **NEONEMERTEA**

Order **POLYSTILIFERA**

Suborder **Reptantia**

Six species of the eureptantian nemerteans were found in our materials but identification of these species is problematic, as most of the known tropical reptantians from the Pacific and Indian Oceans were described without data on the colour pattern of living specimens (see Stiasny-Wijnhoff, 1936). In our material only two species possessed a uniformly coloured body (Eureptantia gen. sp. 1 and Eureptantia gen. sp. 3). Other species have different colour patterns of the body, especially complicated on the head (Fig. 8A–E).

Order **MONOSTILIFERA**

Suborder **Cratenemertea**

Family **Cratenemertidae**

Genus *Nipponnemertes* Gibson et Crandall, 1989

(=*Nipponnemertes* Crandall, 2001 syn. n.)

The genus *Nipponnemertes* Friedrich, 1968 was established without designation of the type species and this name is unavailable (see Crandall, 2001). Gibson and Crandall (1989) designated *Amphiporus drepanophoroides* Griffin, 1898 as the type

species of *Nipponnemertes*; this means that Gibson and Crandall are the authors of the available name *Nipponnemertes*. *Collarenemertes* is probably a junior synonym of *Nipponnemertes* because now there are no substantial differences between these genera.

***Nipponnemertes* sp.**

Figs. 8F; 10D

Material. 2 specimens, 19th May 2010, Cu Lao Thu Island, 10°31' N, 108°55' E, depth 6–8 m, dead corals.

Description. Body narrow, 14–30 mm long, head rounded; anterior cephalic furrows with secondary grooves, posterior furrow (neck furrow) V-shaped on dorsal side. On each side of head about 15–17 large eyes arranged in two longitudinal rows in front of anterior furrow and one large eye situated just behind furrow. Body uniformly pale orange. Blood red. Basis of central stylet rounded, stylets as long as 2.4 basis length, accessory stylets in two pouches. Proboscis with 10 nerves.

Suborder **Eumonostilifera**

Family **Ototyphlonemertidae**

Genus ***Ototyphlonemertes*** Diesing, 1863

Ototyphlonemertes (Norenburgia) ani Chernyshev, 2007

Material. 7 specimens, 9th January 2005, Van Phong Bay, 12°35' N, 109°20' E, intertidal, sand.

Description. Body 4–5 mm long, whitish, without adhesive end, cephalic cirri not found, caudal cirri present. Cerebral organs small. Statocysts with polygranular statoliths, each statolith consisting of 23–24 granules. Anterior proboscis chamber 300–500 µm long, proboscis papillae very short; stylet region 165–180 µm long, with long *ductus ejaculatoris*; baloon 132–156 µm long but not tubular; posterior proboscis region up to 400 µm long; S=36–45 µm, B=24–29 µm, S/B=1.26–1.75, B/b=4.9–6.1; stylets with two spiral strands; two accessory pouches with 2–7 stylets directed backward. Intestine with short simple lateral pouches.

Distribution. Vietnam (only type location).

Ototyphlonemertes (Ototyphlonemertes) cf. martynovi Chernyshev, 1993

Material. 1 specimen, 10th January 2005, Van Phong Bay, 12°39' N, 109°20' E, intertidal, sand.

Description. Body 6–7 mm long, whitish, with a caudal adhesive plate. Cerebral organs present. Statocysts with two simple statoliths. Cirrial formula: A=0,

B=1–2, C=2–3, D=1–2, E=0, caudal cirri 2–3 pairs. S=34 μ m, B=35 μ m, b=13 μ m, stylets smooth, two accessory pouches with 2 stylets in each, directed forward; gland ring in stylet region weakly developed.

R e m a r k s. The specimen is very similar to *Ototyphlonemertes* sp. II Kirsteuer, 1977 and differs from *O. martynovi* Chernyshev, 1993 from the Sea of Japan in the cirrial formula and weak development of the glands in the stylet region.

Family **Poseidonemertidae**

Genus *Diplomma* Stimpson, 1857

Diplomma serpentina (Stimpson, 1855)

Figs. 8A–C; 11A–C

M a t e r i a l. 1 specimen, 18th May 2007, Tonkin Bay, Dang Khoa Island, 20°58' N, 107°34' E, intertidal, calcareous red algae; 4 specimens, 23rd May 2007, Cu Lao Re Island, 15°23' N, 109°05' E, depth 2–4 m, dead corals; 2nd June 2007, Van Phong Bay, Hon Lon Island, intertidal, dead corals; 4 specimens, 13th May 2010, Tho Chu Island, 09°19' N, 103°30' E, depth 3–5 m, dead corals; 15th May 2010, Nam Du Island, 09°43' N, 104°23' E, intertidal, calcareous red algae; 1 specimen, 18th May 2010, Cu Lao Thu Island, 10°32' N, 108°55' E, depth 3–5 m, dead corals; 3 specimens, 21st May 2010, Van Phong Bay, 12°40' N, 109°20' E, intertidal, calcareous red algae; 2 specimens, 26th May 2010, Cu Lao Cham Islands, 15°54' N, 108°32' E, depth 1–2 m, dead corals.

D e s c r i p t i o n. External features. Body 1.5–6 cm long, narrow, head wider than body, slightly widened in brain region (because of large brain), with anterior and V-shaped posterior cephalic furrows but the second usually difficult to observe in living specimens. Body uniformly purple brown (colour of liver) with unpigmented margin on anterior head edge. Eyes not visible in living specimens because of body pigmentation; they are arranged in two irregular groups or oblique rows on each side (1–6 eyes in each group or row).

Internal morphology corresponds to the first description excluding number of the proboscis nerves (Kajihara et al., 2011). Dorso-ventral muscles passing laterally to brain (Fig. 11B) and lateral nerve cords (Fig. 11A). Lateral nerve cords with 3–5 myofibrillae. Septa closed, well-developed (Fig. 11D). Proboscis with 11–15 main nerves, secondary (false) nerves present (Fig. 11C). S/B=1.32–1.71 (n=6), accessory stylets in two pouches, 2–4 in each.

D i s t r i b u t i o n. Philippines, Indonesia, Japan (Okinawa and Honshu islands) (Kajihara et al., 2011), Vietnam, and Guam (unpublished data).

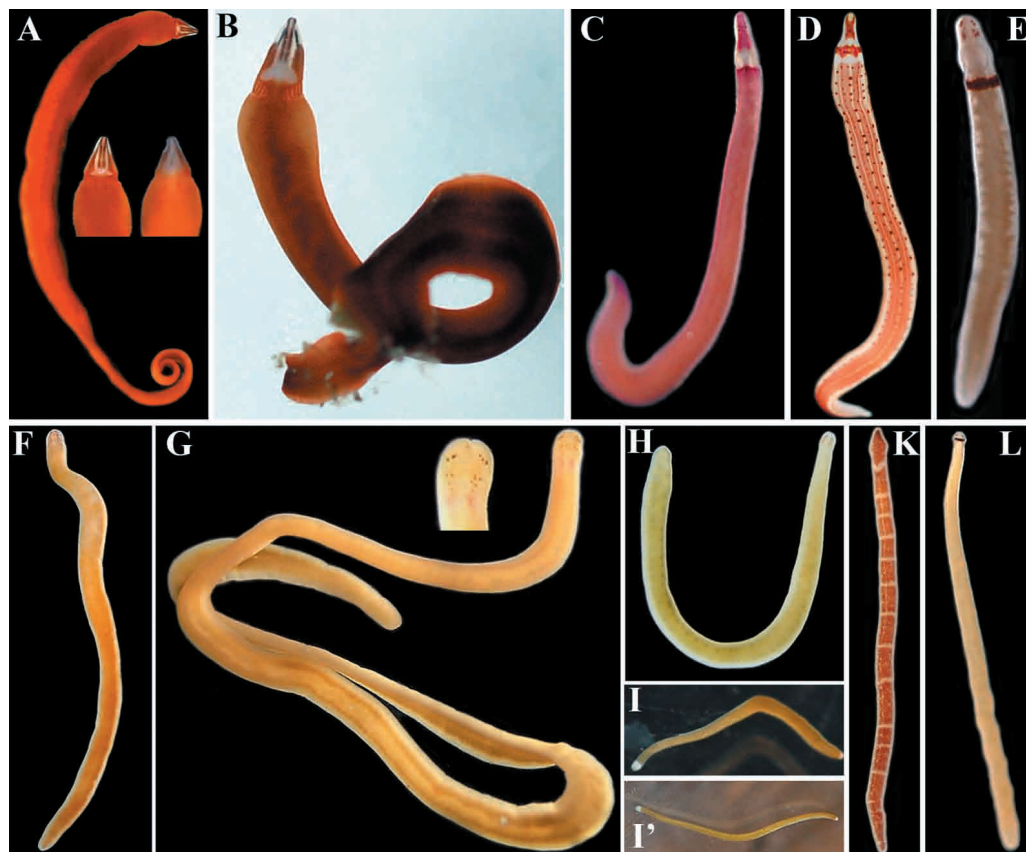


Fig. 8. (A) Drepanophoridae gen. sp. 1 (Van Phong Bay); (B) Drepanophoridae gen. sp. 2 (Tho Chu Island); (C) Drepanophoridae gen. sp. 3 (Cu Lao Thu Island); (D) Drepanophoridae gen. sp. 4 (Van Phong Bay); (E) Eureptantia gen. sp. 2 (Cu Lao Thu Island); (F) *Nipponnemertes* sp.; (G) Eumonostilifera gen. sp. 1 (Tonkin Bay, Dang Khoa Island); (H) *Tetrastemma* ex gr. *roseocephalum*; (I, I') *Tetrastemma albomaculatum* sp. n.; (K) Eumonostilifera gen. sp. 12; (L) *Tetrastemma* sp. 15 (Cu Lao Cham Islands).

Remarks. This species was distinguished from other species of *Diplomma* by having 12 proboscis nerves (Kajihara et al., 2011); however, the specimens from Vietnam have 11–15 nerves. Comparison of the COI sequences showed that our specimens belong to *D. serpentina* (Dr. Malin Strand, personal communication).

Family Tetrastemmatidae

The majority of the hoplonemerteans in our material belongs to the family Tetrastemmatidae. *Tetrastemma* and *Tetrastemma*-like species from Vietnam can be provisionally classified into five groups: 1) uniformly coloured without patches

and stripes (Fig. 9F, G, I); 2) with a dark (black or dark brown) patch or patches on the head (“*melanocephalum*” and “*coronatum*” groups) (Figs. 8L; 9E, K, M, N); 3) with a red, brown-red, violet or orange patch (or patches) on the head (Figs. 8H; 9A, C, D); 4) with a white patch on the head but without dark or reddish pigment (Figs. 8I; 9B, L); 5) with two brown longitudinal stripes (Fig. 9J). Here I describe two species of *Tetrastemma*, two species previously assigned to the genus *Nemertellina*, and one unusual *Tetrastemma*-like species.

Genus *Tetrastemma* Ehrenberg, 1828

Tetrastemma ex gr. roseocephalum (Yamaoka, 1947)

Figs. 8H; 9A; 10E, E'

Tetrastemma roseocephalum (Yamaoka, 1947): GenBank: AB725598.1.

Material. 2 specimens, 18th May 2007, Tonkin Bay, Dang Khoa Island, 20°58' N, 107°34' E, intertidal, calcareous red algae.

Description. Body 10–12 mm long, yellowish, dorsal side with white dots (especially numerous on posterior portion); head with anterior cephalic furrows and V-shaped posterior (neck) furrow; 4 eyes, anterior pair larger than posterior one; first specimen with two thin orange patches connecting anterior and posterior eyes, second specimen with additional transverse orange patch between posterior eyes. B=90 and 105 μ m, S/B=0.90–0.96, B/b=3.15–3.25, two accessory pouches with 2 stylets in each.

Remarks. GenBank sequences indicate that *T. roseocephalum* appears to comprise at least three cryptic species from Japan, Vietnam and China, respectively (Leisi, Norenburg, 2014).

Tetrastemma albomaculatum sp. nov.

Figs. 8I, I'; 9B; 10F; 12D–F

Material. Holotype (transverse sections, N 29888), 13th May 2010, South China Sea, Vietnam, Cu Lao Thu Island, 10°32' N, 108°55' E, depth 6–9 m, dead corals, coll. A.V. Chernyshev.

Description. External features. Body 7 mm long, slender, head rounded, anterior cephalic furrows long, clearly visible on dorsal and ventral surfaces, posterior (neck) furrow V-shaped on dorsal surface; 4 eyes, anterior about 20 μ m in diameter, posterior about 14 μ m in diameter. Ground colour pale ochre, dorsal surface with small white dots, head with rounded white patch, posterior body end also white. Blood colourless.

Internal morphology. Epidermis 40–50 μ m, dermis very thin. Longitudinal body musculature not divided anteriorly. Rhynchocoel as long as body length. S=63 μ m, B=76 μ m, b=38 μ m, posterior end of basis truncated, two accessory

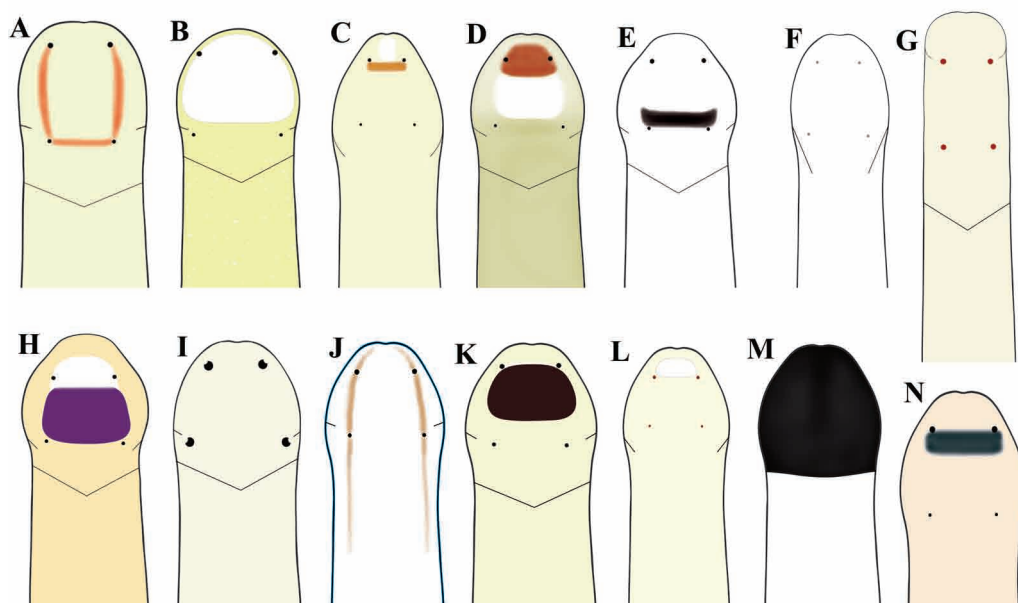


Fig. 9. Schematic pictures of the head of *Tetrastemma* and *Tetrastemma*-like species from Vietnam. (A) *Tetrastemma* ex gr. *roseocephalum*; (B) *Tetrastemma albomaculatum* sp. n.; (C) *Tetrastemma* sp. 1 (Bach Long Vi Island); (D) *Tetrastemma* sp. 2 (Bach Long Vi Island); (E) *Tetrastemma* sp. 3 (Cu Lao Re Island); (F) *Tetrastemma* sp. 6 (Vanguard Bank, depth 72–87 m); (G) *Nemertellina* sp. 1 (Bach Long Vi Island); (H) *Tetrastemma* sp. 7 (Vanguard Bank, depth 72–87 m); (I) *Tetrastemma* sp. 9 (Vanguard Bank, depth 72–87 m); (J) *Tetrastemma* sp. 10 (Van Phong Bay); (K) *Tetrastemma* sp. 11 (Hon Cau Island); (L) *Tetrastemma* sp. 12 (Hon Cau Island); (M) *Tetrastemma* sp. 16 (Cu Lao Cham Islands); (N) *Eumonostilifera* gen. sp. 3.

pouches with 2–3 stylets in each. Lateral nerve cords without accessory nerves. Foregut with esophagus, stomach and long pylorus; anterior pouches of intestinal caecum reaching dorsal ganglia. Cerebral sensory organs large, situated close under antero-lateral margins of brain, extending back to level of ventral cerebral commissure and opening to exterior via ventro-lateral cerebral canals. Frontal organ present. Cephalic glands ending near precerebral septum, ventral lobe more developed and compact. Mid-dorsal vessel with vascular plug.

Remarks. The new species differs from other species of the genus *Tetrastemma* in the body colour pattern.

Genus *Nemertellina* Friedrich, 1935

Nemertellina sp. 1

Figs. 9G; 10G

Material. 2 specimens (mature female and immature specimen), 21st May 2007, Bach Long Vi Island, 20°08' N, 107°44' E, depth 3–5 m.

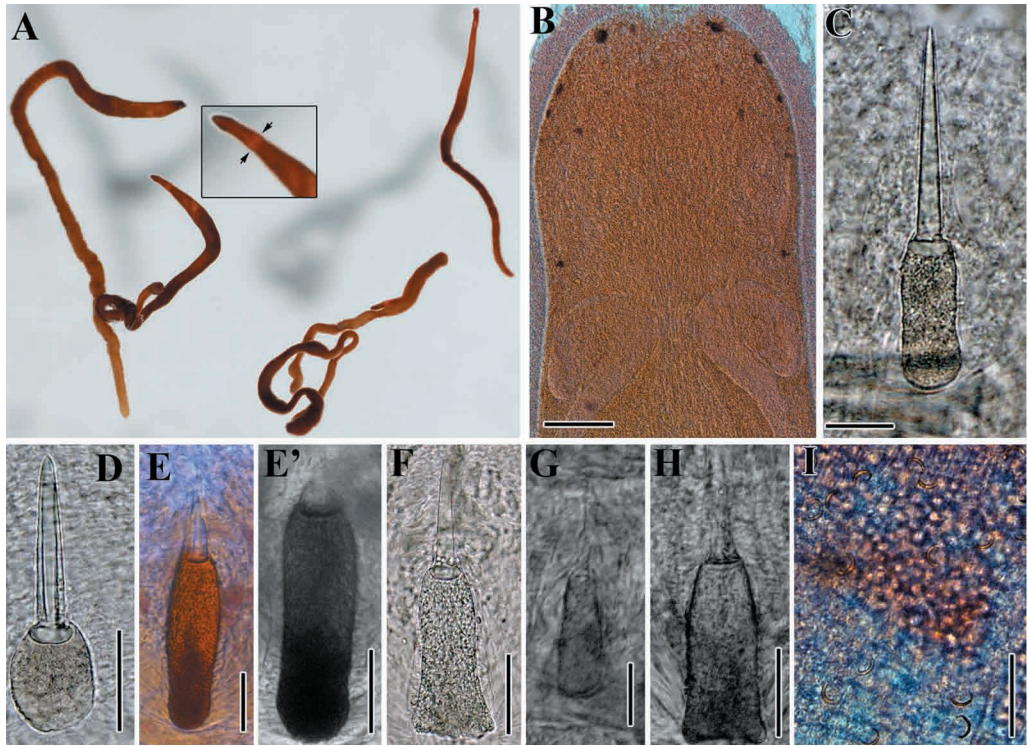


Fig. 10. Living worms (A) (arrows show wider brain region), squeezed head (B), central stylet and basis (C–H), and epidermal spicules (I); (A–C) *Diplomma serpentina*; (D) *Nipponnemertes* sp.; (E, E') *Tetrastemma* ex gr. *roseocephalum*; (F) *Tetrastemma albomaculatum* sp. n.; (G) *Nemertellina* sp. 1; (H, I) *Eumonostilifera* gen. sp. 3. Scale bars: B – 100 μ m, C–I – 30 μ m.

Description. Body very slender, up to 3 cm long, yellowish; head narrow and long, rounded anteriorly, with short anterior cephalic furrows and V-shaped neck furrow; 4 eyes. Rhynchocoel as long as 1/3 of body length; in mature female basis of central stylet about 50 μ m, S/B about 1, basis elongated oval, B/b=2.12, two accessory pouches with 2 stylets in each. Blood colourless. Gonads arranged irregularly.

Nemertellina sp. 2

Material. 1 immature specimen, 15th May 2010, Nam Du Island, 09°43' N, 104°23' E, depth of 3–5 m, dead corals.

Description. Body slender, up to 6 mm long, yellowish; head narrow, bluntly pointed, with anterior furrows and V-shaped neck furrow; 4 eyes. Rhynchocoel as long as 1/2 of body length; B=55 μ m, S=30 μ m, b=13 μ m, basis elongated. Blood red.

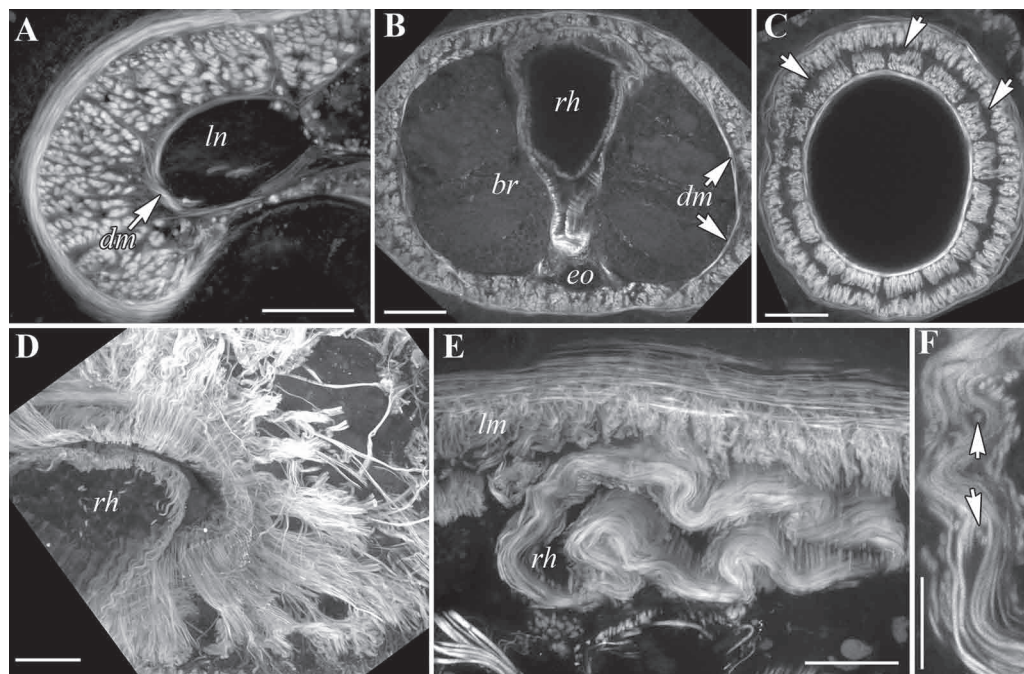


Fig. 11. CLSM micrographs of the transverse sections. (A–D) *Diplomma serpentina* (A – gut region; B – brain; C – proboscis, arrows indicate “false nerves”; D – precerebral septa); (E, F) *Eumonostilifera* sp. 12, rhynchocoel (arrows indicate separate longitudinal muscles in outer circular musculature of rhynchocoel wall). Abbreviations: *br*, brain; *dm*, dorso-ventral muscles; *lm*, body longitudinal musculature; *ln*, lateral nerve cord; *eo*, esophagus; *rh*, rhynchocoel. Scale bars: A–E – 50 μ m, F – 25 μ m.

***Eumonostilifera* sp. 3 (“*Zygotetrastemma*”)**

Figs. 9N; 10H

M a t e r i a l. 1 specimen, 24th May 2007, Cu Lao Re Island, intertidal, among algae.

D e s c r i p t i o n. Body very slender, up to 9 mm long, translucent, pale salmon; head distinct from body, with 4 eyes (posterior eyes smaller than anterior ones) and dark transverse patch between anterior eyes (as in *Tetrastemma coronatum* (Quatre-fages, 1846) group), in glycerol preparation this patch black cyan. Rhynchocoel as long as body length; B=67 μ m, S=50 μ m, b=33 μ m, posterior end of basis truncated. Epidermis containing numerous C-shaped spicules.

R e m a r k s. This species combines characters of the genus *Tetrastemma* (4 eyes, a dark patch on the head) and the family Zygonemertidae (a conical basis with a truncated posterior end and epidermal spicules).

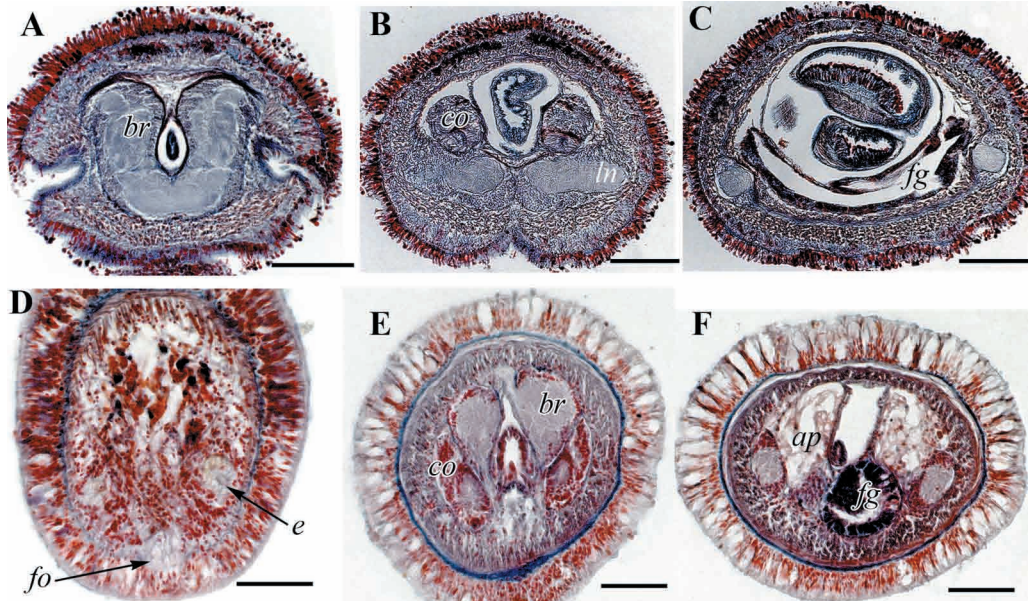


Fig. 12. Transverse (A–C, E, F) and oblique (D) histological sections. (A–C) *Evelineus* cf. *mcintoshii* (A – brain region; B – cerebral organ region; C – foregut region); (D–F) *Tetrastemma albomaculatum* sp. n. (D – anterior end of head; E – anterior end of brain; F – stomach region). Abbreviations: *ap*, anterior pouch of caecum; *br*, brain; *co*, cerebral organ; *e*, eye; *fg*, foregut; *fo*, frontal organ; *ln*, lateral nerve cord. Scale bars: A–C – 100 μ m, D–F – 50 μ m.

Eumonostilifera sp. 12

Fig. 8K

Plectonemertes sinensis: Chernyshev, 2011a, p. 22, fig. 1F (auct. non Gibson, 1990).

Material. 1 specimen, 25th May 2010, Cu Lao Cham Islands, 15°53' N, 108°31' E, depth 1–2 m, dead corals.

Description. External features. Body narrow, up to 23 mm long; head bluntly pointed, diamond-shaped, with long oblique anterior furrows and V-shaped posterior furrow. Ground colour pale reddish brown with 14 transverse whitish rings (first ring V-shaped on dorsal surface), whitish dots and whitish mid-dorsal longitudinal stripe. Proboscis whitish. Blood colourless. Four groups of eyes comprising an anterior row of 11–12 eyes close to each antero-lateral head margin, with two compact groups of about 10 smaller eyes lying dorso-laterally.

Internal morphology. Rhynchocoel wall consisting of inner thinner longitudinal musculature and outer thicker circular musculature (Fig. 11E), a few isolated longitudinal fibres found in circular musculature (Fig. 11F). Proboscis with 11 nerves, S=78 μ m, B=63 μ m, b=27 μ m, basis with a rounded posterior part, two

accessory pouches with 3 stylets in each. Cephalic glands extremely well developed. Longitudinal body musculature splitting in brain region. Vascular plugs not found.

Remarks. The colour pattern of the examined specimen closely resembles that described for *Plectonemertes sinensis* Gibson, 1990, but the internal morphology (eleven proboscis nerves and two-layered rhynchocoel wall) is quite unlike that described for this species (Gibson, 1990).

Discussion

The material examined has indicated the presence of the twelve species new to the fauna of the coastal waters of Vietnam: *Cephalotrichella alba*, *Cephalothrix* cf. *fasciculus*, *Baseodiscus jonasii*, *Notospermus tricuspidatus*, *N. geniculatus*, *N. albovittatus*, *Micrura callima*, *Lineus binigrilinearis*, *L. fuscoviridis*, *Evelineus* cf. *mcintoshii*, *Eousia verticivaria*, and *Diplomma serpentina*. Originally described from Australia, *Micrura callima* (Sundberg, Gibson, 1995), is detected to be common to Vietnam together with *Diplomma serpentina*, recently redescribed from Japan, Philippines and Indonesia (Kajihara et al., 2011). Two such species as *L. binigrilinearis* and *E. verticivaria* were previously known only from the coastal waters of Hong Kong, and *B. jonasii* was known from the Solomon Islands. The latter three species as well as *C. alba*, *L. fuscoviridis* and *N. albovittatus* seems to have wide distribution in the Tropical waters of the Indian and Pacific Oceans (as is the case for *N. tricuspidatus*). However, further DNA sequences will be strongly needed for exact identification and excluding of possible cryptic species. It is especially so in view of comparison of the COI fragments of *C. alba* from Vietnam and Central America (Belize and the Pacific coast of Panama) which has indicated that these samples belong to two or three different species. Two other species, *Baseodiscus hemprechii* and *N. geniculatus*, have a wide distribution in the tropical and subtropical zones of the World Ocean. Furthermore, if it would be confirmed that *Micrura* cf. *aurantiaca* and *Evelineus* cf. *mcintoshii* belong respectively to *M. aurantiaca* and *E. mcintoshii*, the latter two species can also be recognized as being widely distributed.

It remains unclear whether there are widely distributed species among the hoplonemerteans collected in Vietnam. At least, some species of *Tetrastemma* seems to be very similar to congeners from the coast of Europe. A specific feature of tropical fauna is the occurrence of the polystiliferous nemerteans (Reptantia) that inhabit some coral communities. Unfortunately, most species of Reptantia were described without any data based on live specimens, and thus rendering the precise identification of these nemerteans is quite difficult.

Undoubtedly, much diverse nemertean fauna can be expected to occur in the coastal waters of Vietnam, most likely, exceeding 140–160 species. This figure is close to the data of nemertean diversity (120–140 species) known in Hong Kong – the most well-studied region along the Asian tropical-subtropical coast (Gibson, Sundberg, 2003). For comparison, only 82 nemertean species are known for the British Isles (Gibson, 1994) and 100 species – for the Sea of Japan (Chernyshev, 2014). Apparently, the greatest number of undescribed species and genera of ribbon worms exists in the tropical seas. It seems very unlikely to prepare a comprehensive description of this fauna and to estimate its true diversity in the near future. Further investigations of tropical nemerteans seem to be impossible without use of methods of DNA taxonomy. However, the systematic description of nemerteans still cannot be conducted without examination of their internal morphology, as is proposed by some modern authors.

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Biodiversity of bivalve mollusks in the western South China Sea: an overview

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Abstract: A history of molluscan research in the western South China Sea (Singapore, Peninsular Malaysia, Thailand, Cambodia, Vietnam and China) is described with main references provided. The South China Sea has the most diverse bivalve fauna in the world from 1200–1500 species. Regional species richness of bivalve mollusks in the western sea area varies from 344, at Singapore in the south, to 822, southern mainland China in the north, more of an indication of sampling efforts and the state of knowledge of the fauna than real biodiversity gradients. Other biodiversity-rich areas include the Gulf of Thailand (594 species), Vietnam (815), Tonkin Gulf (368) and Hong Kong (299). The western part of the South China Sea is divided between two provinces: the truly tropical Indo-Polynesian Province, and the subtropical Sino-Japanese Province; the boundary point lies around Hong Kong. Biogeographical problems as related to Vietnamese bivalve fauna are highlighted, and the biogeographical zonation of the South China Sea based on concepts of western, Chinese, and Russian researchers is discussed. Problems in studying the region's bivalve biodiversity include inflated synonymy, a lack of trained, regionally-based taxonomists, good voucher collections, and a lack of funding for taxonomy. Threats to molluscan biodiversity are also discussed. Photographs of 117 species of bivalves belonging to 28 families are provided.

Key words: Bivalvia, South China Sea, biodiversity, history, biogeography.

The South China Sea has an area of some 3.3 million km² and depths to 5377 m in the Manila Trench, thus being the biggest sea in the World Ocean. The sea has also numerous islets, atolls, and reefs, and it experiences a monsoonal climate, being influenced by the Southwest Monsoon in summer and the Northeast Monsoon in winter. The South China Sea is a marginal sea and largely surrounded by land. Countries around the sea include China, Malaysia, the Philippines, Vietnam, Cambodia, Thailand, Singapore, Indonesia, and Taiwan. The coastal fringes of the South China Sea are home to about 270 million people that have had some of the fastest-developing and most vibrant economies on the globe. Consequently, anthropogenic

impacts, such as over-exploitation of resources and pollution, are anticipated to be huge although, in reality, relatively little is known about them (Morton, Blackmore, 2001). There are 93 cities each with a population of more than 100,000.

The South China Sea is poorly understood in terms of its marine biota and ecology but it lies in probably the world's most diverse shallow-water marine area (Briggs, 1974; Hoeksema, 2007; Veron et al., 2009; Briggs, Bowen, 2013; Gaither, Rocha, 2013; etc.). For instance, the fish fauna of the South China Sea includes at least 2321 species belonging to 35 orders, 236 families, and 822 genera, compared with 3048 species of fish occurring in all China seas (Ma et al., 2008). The Philippine Islands have been called the “center of the center” of marine shore fish biodiversity (Carpenter, Springer, 2005).

The purpose of this paper is to bring together knowledge about the overall biodiversity and species richness of bivalve mollusks, one of the most abundant and ecologically important benthic groups of animals of the western South China Sea, to provide a comprehensive bibliography, and to highlight some biogeographical and taxonomic problems.

Geographically, we consider only the fauna of the western, continental part of the South China Sea, excluding Taiwan, but including Hainan Island. According to Limits... (1953), the sea, Region 49, is limited on the south by the eastern and southern Singapore and Malacca Straits as far west as Tanjong Kedabu (1°06' N, 102°58' E), down to the east coast of Sumatra to Lucipara Point, and on the north from southern Taiwan westward on the parallel of 25°24' N to the coast of Fukien (=Fujian Province of China). The Gulf of Thailand, historically, the Gulf of Siam, is a shallow arm of the South China Sea limited by a line running from Cape Cà Mau (Mũi Cà Mau) (southern Vietnam) to Kota Bharu (Kelantan) in Malaysia. The Gulf is shallow with maximum depth of 85 m. Some researchers include the South China Sea in the Sundaland region, in the marine realm. This region encompasses the Andaman Sea, South China Sea, Sunda Shelf, Java Transitional, and Western Coral Triangle marine biogeographic provinces (Chan et al., 2014). R. Kilburn (1997) used the term “Malesia” when considering the molluscan fauna of the Malaysian and Philippines region, and most of Indonesia from the Andaman Sea to the Weber Trench north to the Gulf of Thailand.

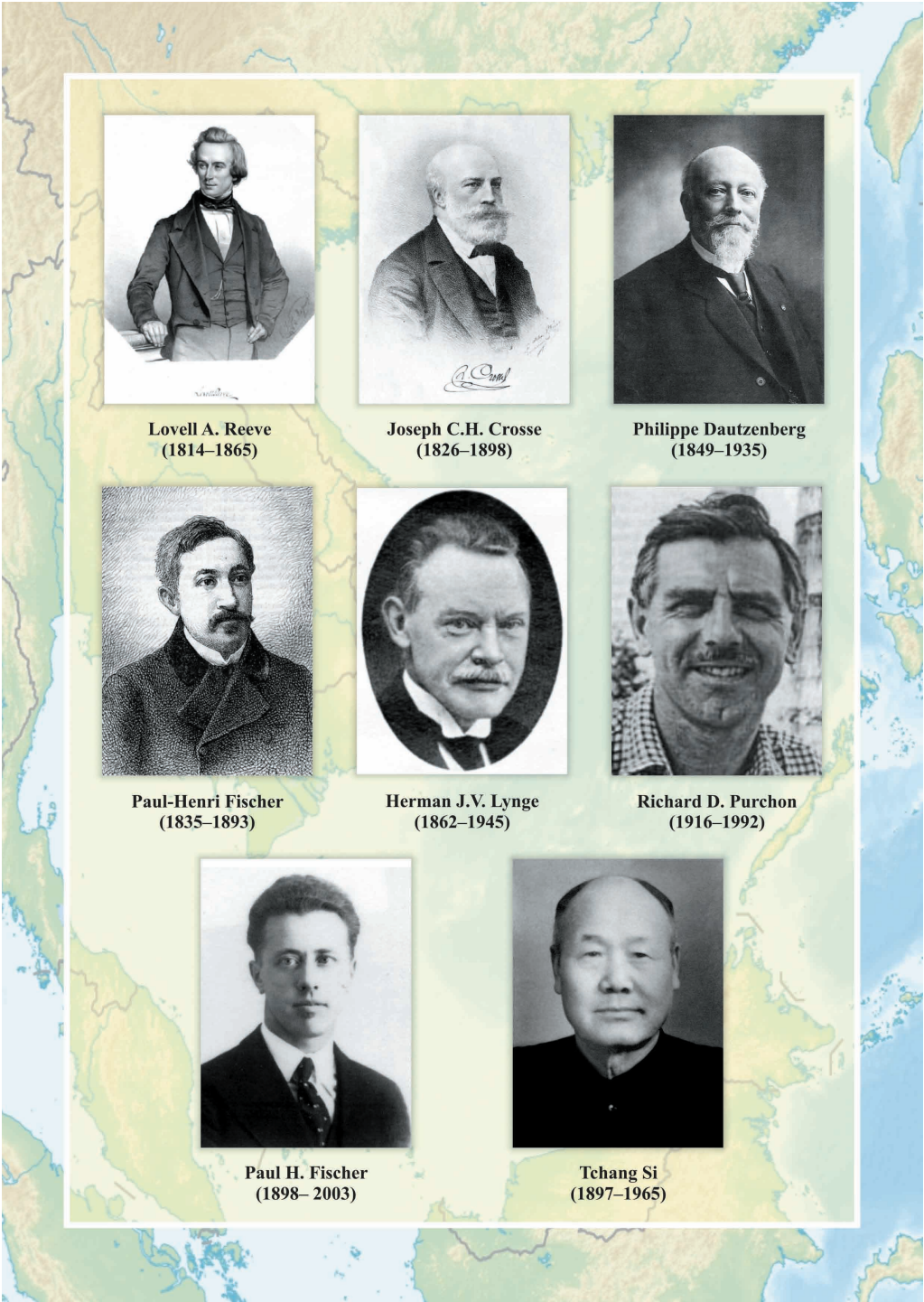
A history of molluscan research

The first European shell collecting in the region was probably during the visit to Poulo Condor Island (Con Dao, or Côn Sơn Archipelago, in southern Vietnam) by the ships *Resolution* and *Discovery* of Captain James Cook's third expedition,

under the command of Captain John Gore in January 1780; Cook had been killed in February 1779 (Fischer, 1987). Most of the shells from the last Cook voyage went to Thomas Martyn (1760–1816), who published *The Universal Conchologist* in four volumes with attractive illustrations (Dance, 1966, 1971). Then a portion of this area, Singapore and Vietnam, was visited by the French ship *La Bonite*, under the command of Captain Auguste-Nicolas Vaillant in 1837, and the shells collected were described later by a French conchologist, Louis François Auguste Souleyet (1811–1852) (Fischer, 1987). The outstanding shell collector of the nineteenth century, Hugh Cuming (1791–1865) visited some areas of the western South China Sea, e.g., Singapore, during his 1839 travels (Dance, 1966). Cuming's collection of almost 83,000 specimens was purchased by the Natural History Museum in London (then the British Museum (Natural History)) in 1866. His, and other collections of that time, were examined by the well-known malacologists Lovell Augustus Reeve (1814–1865) (Fig. 1) and George Brettingham Sowerby I (1788–1854), II (1812–1884), and III (1843–1921). The most important works containing species from this area include Reeve's *Conchologia Iconica* (1843–1878, 20 volumes) and the Sowerbys' *Thesaurus Conchyliorum* (1842–1887, five volumes) (Clench, 1945; Dance, 1980). Many type localities for new species described in their works were designated as “China” or “China Seas”, “Singapore”, some as “Cochin China” (e.g., *Venus cochinensis* G.B. Sowerby II, 1853), “Hong Kong” (e.g., *Psammobia simplex* G.B. Sowerby III, 1894) (Petit, 2007, 2009). Arthur Adams (1820–1878), a prominent British malacologist, participated in the voyage of the HMS *Samarang* under the command of Captain Edward Belcher, and this ship visited Singapore and Hong Kong on several occasions in 1843–1844 (Adams, 1848; Belcher, 1848). Mollusks collected during this expedition were described in the *Zoology of the Voyage of H.M.S. Samarang* (Adams, Reeve, 1848–1850). Indeed, many localities mentioned in the latter book refer to the “China Seas”. A. Adams was the ship's doctor on board HMS *Actaeon* during a trip to the Sea of Japan, Korea, and China in the 1850s–1860s where he collected many new species and subsequently described them, along with shells from the Cuming collection, in a series of papers, often briefly and without illustrations (Dance, 1966).

China and Hong Kong

Chinese and foreign contributions to the study of marine bivalves, including those of the South China Sea, were reviewed and summarized by Q. Zhuang (1992) and partly by P. Valentich-Scott (2003), and recently by J. Zhang et al. (2014). Collected material is housed mainly in the Institute of Oceanology, Chinese Academy of Sciences, Qingdao. Chinese malacologists published a number of important



taxonomic monographs in the series *Fauna Sinica*, such as those on the Pteriina (Wang, 2002), Protobranchia and Anomalodesmata (Xu, 1999), Mytiloidea (Wang, 1997), Veneridae (Zhuang, 2001), and Lucinoidea, Carditoidea, Crassatelloidea and Cardioidea (Xu, 2012) as well as many other papers. An important contribution to the Chinese molluscan fauna, a study on Tellinoidea, was made by the Russian malacologist O.A. Scarlato (1965). Two catalogues of bivalve mollusks of the Chinese seas were published in the 1990s (Bernard et al., 1993; Xu, 1997). Chinese malacologists also described many new species including those from the South China Sea; type material of these species was recently reviewed and illustrated (Lutaenko, Xu, 2008).

The most comprehensive Chinese monograph by Tchang Si et al. (1960) (Fig. 1) on bivalves of the South China Sea is outdated, but recently two well-illustrated guidebooks on the entire Chinese fauna were published (Qi, 2004; Xu, Zhang, 2008). Chinese malacologists have recently published color guidebooks on the bivalve fauna of some localities in the South China Sea and surrounding areas, such as Hainan Island (Xu et al., 1993) and Daya Bay (Li et al., 2008), and the East China Sea (Dongtou Island, Zhejiang) (Zhang et al., 2012), but the species composition of mollusks in these books is presented selectively. Hainan fauna was also studied jointly by Chinese and Japanese malacologists (Hasegawa et al., 2001). There is a field guide to the mollusks of Guangdong Province illustrated with line drawings (Cai, He, 2006), and a color guidebook of economic mollusks from the South China Sea (Yang et al., 2013). Other books with color illustrations on the bivalves of China have also been published (Wang et al., 1988; Huang, Lin, 2012).

The Hong Kong bivalve fauna has received special attention in the past 40 years. The first combined list of mollusks of Hong Kong and southern China was compiled by Tsi and Ma (1982). A checklist with full bibliography on all aspects of bivalve biology and ecology in the area, with 278 species partly illustrated by color photographs, was published (Valentich-Scott, 2003); an earlier paper of this author was devoted to bivalves of south-eastern Hong Kong (Scott, 1994). Other papers dealt specifically with some taxonomic groups of Hong Kong bivalves: a review of Galeommatoidea (Morton, Scott, 1989), taxonomic accounts of Ostreidae, and Gryphaeidae (Morris, 1985; Lam, Morton, 2003, 2004) and Mytilidae (Lee,

Fig. 1. Malacologists of the 19th–20th centuries contributed to bivalve mollusk's studies of the South China Sea (sources of portraits: <http://www.boghandleridanmark.dk>; <http://www.tmbi.gu.se>; <https://fr.wikipedia.org>; <https://upload.wikimedia.org>; <http://gw.geneanet.org>; Marmont, Ponder, 2004; Zhang et al., 2014).

Morton, 1985a), a review of Donacidae (Ansell, 1985), mollusks associated with corals (Dudgeon, Morton, 1982), a series of papers on the arcoid bivalves (Oliver, 1985, 1986a, b), an illustrated list of shell-bearing mollusks from underwater caves of Hong Kong (Lam et al., 2008), and studies of mangrove mollusks (Cai et al., 1997, 1998). Some data and illustrations of common bivalves are contained in the guide-books of rocky and sandy shores (Williams, 2003; Chan, Caley, 2004). Lutaenko and Volvenko (2013) recently enumerated, and illustrated with taxonomic comments, 77 species from Hong Kong, updating P. Valentich-Scott's list (l.c.) with an additional 21 species. Therefore, 299 species of marine bivalves are currently known for Hong Kong waters.

Vietnam and Cambodia

Mollusks of Indochina, and Vietnam itself, were extensively studied by French malacologists in the second half of the nineteenth century and throughout the twentieth century. French scientists who contributed much to the study of the Indo-China bivalves were Joseph Charles Hippolyte Crosse (1826–1898), Paul-Henri Fischer (1835–1893), Laurent-Joseph Morlet (1823–1892), Jules François Mabilie (1831–1901), Georges Le Mesle (1828–1895), Pierre Marie Henri Fischer (1865–1916), Paul-Henri Fischer (1898–2003; France/Australia), Edouard Fischer-Piette (1899–1988) (Fig. 1) (see: Poyard, 1898; Marmont, Ponder, 2004; and more bibliographic references in Coan, Kabat, 2015). Another eminent scientist who studied Indo-China mollusks, Philippe Dautzenberg (1849–1935) (Fig. 1), was a Belgian malacologist; he assembled a large part of the shell collection of the Royal Belgian Institute of Natural Sciences, which consists of 9,000,000 specimens and is one of the three biggest shell collections in the world (Lamy, 1935; Dance, 1966; Duchamps, 1999). These zoologists published many key papers which are still a major source of faunal information about the regional bivalve fauna (Crosse, Fischer, 1864, 1889, 1890, 1892; Le Mesle, 1866; Mabilie, Morlet, 1886, 1889; Fischer, 1891; Dautzenberg, Fischer, 1905, 1906; and others). For a full bibliography see Serène (1955, pp. 26–30) and Fischer (1987). An important catalogue by P. Fischer (1891) of terrestrial, freshwater, and marine mollusks of Indo-China (Siam, Laos, Cambodia, Cochinchina, and Annam and Tonkin¹) contained 1129 species including 477 marine species belonging to 133 genera. R. Serène (1937) and C. Dawydoff (1952)

¹ Cochinchina (Vietnamese: Nam Kỳ, French: Cochinchine) is a region encompassing the southern third of Vietnam; the principal city is Saigon (now Ho Chi Minh City); Annam (Vietnamese: An Nam or Trung Kỳ) was a French protectorate encompassing the central region of Vietnam; Tonkin (Vietnamese: Bắc Kỳ, historically Đàng Ngoài), also spelled Tongkin, Tonquin or Tongking, is the northernmost part of Vietnam, south of China's Yunnan and Guangxi provinces.

published inventories of invertebrates of Indochina. French studies of the bivalves of Vietnam and Cambodia were then summarized by P.-H. Fischer (1973, 1987) and P.-H. Fischer and Fischer-Piette (1972). Many taxonomic revisions of mollusks of French authors (V. Bertin, E. Lamy, E. Fischer-Piette and others) based on collections of the Muséum National d'Histoire Naturelle in Paris contain South China Sea records.

The most important Russian contribution to studies of the benthic fauna of Vietnam was E.F. Gurjanova's (1972b) paper dealing with the fauna of Tonkin Gulf and its ecological and biogeographical traits. She compiled a list of species found in this area by the II Soviet-Vietnamese expedition (1961), the Soviet-Chinese expedition to the western coast of Hainan Island (1959) and those mentioned in two previous lists by Serène (1937) and Dawydoff (1952). This list included 104 bivalve species, among them 18 identified to the genus level; all species were identified by the Russian malacologist O.A. Scarlato (1920–1994). A detailed description of the Hainan and Vietnam expeditions with maps of the sampling areas is given by Gurjanova (1959, 1962). An examination of catalogue cards of the Zoological Institute, Russian Academy of Sciences, St. Petersburg, reveals that Scarlato studied part of the Vietnamese material.

The study of the Vietnamese and southern Chinese molluscan collections in Russia was continued by Irina P. Zorina (1928–1995), who published three papers dealing with the ecology, distribution, and taxonomy of the Tonkin Gulf bivalve fauna (Zorina, 1975, 1978a, b). In total, she identified 351 species belonging to 150 genera and 49 families (Zorina, 1978a), but a complete species list has never been published except for the enumeration of 140 species from seven selected families (Zorina, 1975). However, Zorina prepared a card catalogue of the studied collection in the Zoological Institute, and a list of species of the entire Vietnam coast was later published by K.A. Lutaenko (2000b), combined with additional data from other Russian museums and publications, with comments and illustrations of type material. Other Russian contributions in the field of biology and ecology of Vietnamese bivalves in the 1970s–1990s were reviewed by Lutaenko (2000a). Data on the Tonkin Gulf bivalve fauna has been updated by lists prepared by Vietnamese researchers for Cat Ba and Co To islands, Ha Long Bay and the entire Tonkin Gulf (Nguyen Xuan Duc et al., 1997; Do Cong Thung, 2001, 2007; Nguyen Xuan Duc, 2001; Nguyen Quang Hung, 2007) but none of these lists are illustrated.

There is a number of other national Vietnamese papers on molluscan biodiversity (see review in Hylleberg, Kilburn, 2003; Hylleberg, 2014). Bui Quang Nghi (2000) published some data on bivalves of sea grass communities in Van Phong and Cam Ranh bays, southern Vietnam. Hua Thai Tuyen (1999) provided a checklist of marine mollusks of Con Dao Islands in southern Vietnam. Nguyen Van Chung and

Huynh Minh Sang (2004) reviewed the molluscan fauna of Binh Cang – Nha Trang Bay based on six surveys during 1977–2000. Dinh Van Hai and Doan Dang Phi Cong (2007) studied the species composition of mollusks in seabed areas associated with oil and gas exploration in southern Vietnam, where they identified 187 bivalve species. Nguyen Van Chung and Ha Le Thi Loc (2007) conducted nine surveys along the Ninh Thuan – Ca Mau coasts (1978–2004) at depths down to 50 m and collected 65 bivalve species. Nguyen Van Chung (2003) identified 30 species of bivalves in lagoons of the southern part of central Vietnam. All these papers do not contain illustrations of mollusks, and the location of voucher material is unknown. This restricts the usefulness of Vietnamese national data; moreover, the reliability of identifications is doubtful because of a lack of bivalve taxonomists in this country.

Hylleberg (2000) presented a preliminary checklist of mollusks collected by the members of the Tropical Marine Mollusk Programme (TMMP) in Vietnam and Cambodia.

The most important, recently-published contributions to the understanding of the biodiversity of mollusks in Vietnam are a list by Fischer (1987), an inventory by Hylleberg and Kilburn (2003), a check-list by Nguyen Ngoc Thach (2002), a list by Chinese authors (Cai, Li, 2002), and three books illustrated in color by Nguyen Ngoc Thach (2005, 2007, 2012). However, the latter books contain many misidentifications and include some species names from other biogeographic areas, e.g., Sea of Japan and northern Japan, that obviously do not live in Vietnam.

A few taxonomic accounts of specific bivalve groups of the region were published: Anadarinae (Arcidae) of Vietnam (Evseev, Lutaenko, 1998), common species of Pteriidae (Nguyen Chinh, 1999b), Mytilidae (Nguyen Chinh, 2001), a list of Vietnamese Arcoida (Hua Thai Tuyen, 1998), and a museum catalogue of Arcidae and Cucullaeidae (Le Thi Hong Mo, 2001).

Additionally, some symbiotic bivalves have been recorded from Vietnam; the presence of *Fungiacava eilatensis* T. Goreau, N. Goreau, Neumann et Yonge, 1968 (Mytilidae), a boring mussel in corals, was observed in Nha Trang Bay (Hoeksema, Gittenberger, 2008). Also, an endosymbiotic bivalve, *Entovalva nhatrangensis* (Bristow, Berland, Schander et Vo, 2010) (Galeommatoidea) in the sea cucumbers, *Holothuria spinifera* (Théel, 1886) and *Holothuria leucospilota* (Brandt, 1835) was described in detail from the same bay (Bristow et al., 2010; Lützen et al., 2011).

Thailand

Perhaps the oldest record of a bivalve mollusk in the Gulf of Thailand was a description of *Pholas siamensis* Spengler, 1792 (= *Pholas orientalis* Gmelin, 1791) (Knudsen, Jensen, 2001). It is interesting that the type specimen of this species is the oldest “wet” specimen in the type collection of the Zoological Museum in

Copenhagen (the Natural History Museum of Denmark, the University of Copenhagen) (l.c.). Martens (1860) published a note on the mollusks of Siam, enumerating only seven species of bivalves. Lynge (1909) systematically described and partly illustrated the Gulf of Thailand bivalve molluscan fauna based on the material of the Danish Expedition to Siam (1899–1900) and enumerated 336 species. The leader of the Danish Expedition was T. Mortensen. This collection is stored in the Zoological Museum, Copenhagen, Denmark. The Danish expedition dredged only in the northern and eastern parts of the Gulf of Thailand, and only down to a depth of about 35 fathoms (64 m). Lynge (l.c.) mentioned that the number of known bivalve species for the Gulf at that time, taking into account French data, was 379. Suvatti (1938) tried to summarize the marine bivalve fauna of Thailand but he enumerated only 153 species, including those from the coast of western Thailand; he missed the above-mentioned Lynge monograph.

Sanpanich (1998) published a check-list of bivalves of Chonburi and Rayong Provinces in east Thailand. This author subsequently presented a list of marine bivalve species occurring along the eastern coast of the Gulf of Thailand, from the Province of Chonburi to Trad, based on 55 sampling sites: 20 were located in Chonburi, 10 in Rayong, 7 in Chanthaburi, and 18 in Trad; a total of 321 species, 43 families, and 118 genera were recorded (Sampanich, 2011). This is the most comprehensive list of bivalves of the eastern Gulf of Thailand up to date. There are some other regional lists containing records from the eastern Thailand coast (Kilburn, Hylleberg, 1998; Gemert, 2003).

Four important contributions were recently published for the southern and northern Gulf of Thailand (Swennen et al., 2001; Robba et al., 2002, 2003, 2007). The former book covers an area of more than 10,000 square km in the southern part of the Gulf of Thailand, roughly between 6° and 7° N, and includes a 100 km wide zone around Pattani between Ban Pak Bang Sakom and Saiburi; in total, 229 bivalve species were found there. The publications of Robba et al. (l.c.) dealt with mollusks recovered from both the Holocene Bangkok Clay and the modern intertidal and shallow sublittoral soft substrata of the northern and western Gulf of Thailand. The work was carried out during several expeditions from 1996 through 2003; at first southwest of Bangkok in the coastal area of Phetchaburi, and more recently also in the Pak Phanang Bay on the eastern coast of peninsular Thailand (Nakhon Si Thammarat Province). All species were illustrated, and a comprehensive bibliography was provided.

Kurozumi et al. (1989) studied shallow-water mollusks at Sichang Island, Chonburi, in the innermost part of the Gulf of Thailand and reported 110 species of bivalves; Samakraman et al. (2009) studied the spatial and temporal variability of intertidal rocky shore mollusks on the same island.

Jensen (2004) undertook a brief comparison of species lists of bivalves of the Gulf of Thailand, including the Cambodian and Malaysian coasts, published between 1889 and 2001, and speculated that little or no change was seen in the number of families over this time interval. However, there is apparently a decrease in the number of species, most conspicuous in the Tellinidae. Those lists were never published but, taking into account the scarcity of modern faunal data from this area, this conclusion seems tentative.

There are several faunal/taxonomic accounts of the bivalves of Thailand: Arcidae (Vongpanich, 1996), Noetiidae (Vongpanich, Matsukuma, 2004), Ostreidae and Gryphaeidae (Yoosukh, Duangdee, 1999; Bussarawit et al., 2010), Solenidae (Tuyacharoen, Matsukuma, 2001) and Mactridae (Vongpanich, 2000), species of *Meretrix* (Veneridae) (Yoosukh, Matsukuma, 2001), and some Tellinidae of the Gulf of Thailand (Simone, Wilkinson, 2008). A survey of venerid bivalves (Veneridae) of the Gulf of Thailand revealed 78 species belonging to 10 subfamilies (Sartori et al., 2008); however, only a few of them were illustrated. Seven species of *Barbatia* (Arcidae) were examined and redescribed from the Gulf of Thailand (García, Oliver, 2008). Valentich-Scott and Tongkerd (2008) recorded 21 species of coral-boring bivalves from the Gulf of Thailand belonging to five families: Mytilidae, Petricolidae, Trapezidae, Pholadidae, and Gastrochaenidae. Seven species of wood-boring bivalves (Pholadoidea) were recorded from the Gulf of Thailand (Yoosukh, Jitkaew, 1997). Scott (1995) provided some brief comments on the infaunal bivalves of the Gulf of Thailand.

Malaysia and Singapore

Although the earliest records of bivalves by European workers go back to the nineteenth century, national studies began later. Chuang (1973) listed more than 400 species of shelled molluscs from Singapore, and almost 500 are included by Chou et al. (1994).

R.D. Purchon (Fig. 1) and D.E.A. Purchon (1981) systematically collected mollusks from both the eastern and western shores of Peninsular Malaysia and also Singapore, in Malaysia during 1973 and 1974, and in Singaporean waters between 1950 and 1960. They subsequently listed 186 bivalve species for both countries (Morris, Purchon, 1981). Although they mentioned that the mollusks were photographed and placed in two collections in Philadelphia and London (Natural History Museum), the illustrations were not published and they also missed Chuang's (1973) list. Later, Tan and Chou (2000) published a short guide to the common seashells of Singapore, and Tan and Yeo (2010) studied the intertidal molluscs of Pulau Semakau in Singapore. The most important, and first detailed, list of

Singaporean mollusks was published recently (Tan, Woo, 2010), enumerating 344 species of bivalves.

In recent years, some taxonomic papers on Singaporean bivalves and new species records have been published: Donacidae (Tan, Low, 2013a), Mactridae (Wong, 2009), Trapezidae (Tan, Low, 2013b), Mesodesmatidae (Chan, 2010), Tridacnidae (Neo, Todd, 2012), Ostreidae and Gryphaeidae in Singapore and Malaysia (Lam, Morton, 2009; Suzana et al., 2011), and some Tellinidae (Tan, 2013).

Angot (1984) provided a list of 84 bivalves species collected from the east coast of Peninsular Malaysia. Recently, Wong and Arshad (2011) summarized national Malaysian studies and databases records, and enumerated 206 bivalve species for Peninsular and East Malaysia (Malaysian Borneo). Schweimanns (1990) published some data on the Malaysian Pholadidae and Teredinidae. The biodiversity and distribution of seven pen species (Pinnidae) from the seagrass beds of Sungai Pulai, Peninsular Malaysia, were described by Idris et al. (2008a, b).

Three other important faunas in the basin of the South China Sea and adjacent waters are those of Taiwan, the Philippines, and Indonesia, and relevant malacological studies are briefly mentioned. The Taiwan fauna was documented in numerous papers including check-lists and several books (Kuroda, 1941; Wu, 1980, 2004; Wu, Lee, 2005; Wu, Cai, 2012; and others). The Indonesian bivalve fauna has been covered in two recent books (Dharma, 1992, 2005) but there may be other special inventories of the entire fauna of which we are unaware. However, some important papers on specific groups have been published, such as Pectinidae (Dijkstra, Kastoro, 1997; Dijkstra, Moolenbeek, 2008); Cardiidae (ter Poorten, 2007), Arcidae (Dharma, 2012). Two older works which are still of great importance include the results of the Dutch “Siboga” expedition to Indonesian seas (Dautzenberg, Bavay, 1912; Prashad, 1932).

The Philippine fauna was reviewed in detail at the beginning of the last century (Hidalgo, 1904–1905; Faustino, 1928), and there were some later works including color guidebooks by amateurs (see: Flessa, Jablonski, 1995). The most recent books of importance are two volumes of *Philippine Marine Mollusks* (vols. 3 and 4) by G.T. Poppe (2010, 2011).

A brief but useful overview of the south-east Asian Veneridae was published by R. Kilburn (2000). Bivalves living in the South China Sea are mentioned in many taxonomic revisions and accounts, and it is beyond the scope of this study to include these papers and monographs. Among important modern contributions reviewing the world fauna of bivalve mollusks with discussions on taxonomy, synonymy, distribution, and variability, and the most complete list of species are two books by Huber (2010, 2015), recommended for any student of the tropical Indo-Pacific fauna.

Bivalve richness

We still do not know how many species of bivalve mollusks live in the entire South China Sea and its parts. At continental shelf depths of the sea (<200 m), bivalve species diversity ranges from 1000 to 1300, with an obvious maximum in the Philippines (“center of the center”), up to 1400–1500 (Valentine, Jablonski, 2015). Crame (2000) estimated that about 1211 species inhabit the Indonesia-Philippines region excluding both Taiwan and New Guinea, and 1176 species live in the “East China Sea region” (Table 1; Fig. 2). This estimate shows the high diversity of the fauna and can be compared to eastern Australia which has 911 species. However, the entire Japanese bivalve fauna is also rich with 1472 species (Table 1), being one of the richest molluscan faunas in the world; however, Japan extends throughout several climatic and biogeographical zones, from subtropical to boreal (temperate), containing a mixture of warm-water and temperate-water faunas with an admixture of boreal-arctic elements in Hokkaido. For comparison, species richness of marine bivalve mollusks of all Russian seas, including the European and Arctic, is only 432 (Kantor, Sysoev, 2005).

The molluscan diversity pattern of the South China Sea clearly reflects the generally accepted concept of high biodiversity in the so-called “East Indies Triangle”, or **Coral Triangle**; the ranges of many tropical marine species overlap in a centre of maximum biodiversity located in the Indo-Malayan region (Malaysia, the Philippines, Indonesia, and Papua New Guinea) (Hoeksema, 2007). Among other names for this biodiversity hotspot are Wallacea, Indo-Malayan Triangle, Western Pacific Diversity Triangle, Indo-Australian Archipelago, Southeast Asian center of diversity, Central Indo-Pacific biodiversity hotspot, Marine East

Table 1

Species richness of bivalve mollusks in major areas of Sundaland,
Coral Triangle and adjacent areas

Region	Number of species	Reference	Comments/notes
Indonesia–Philippines region	1211	Crame (2000)	Excluding Taiwan and Papua New Guinea
Philippines	512	Flessa, Jablonski (1995)	A compilation based on literature data
Taiwan	759	Wu (1980, 2004)	
China	1104	Xu, Zhang (2011)	
Japan	1472	Higo et al. (1999)	

Indies (Veron et al., 2011). Sometimes it is called the “Golden Triangle” (Lozouet, Plaziat, 2008). The Coral Triangle is recognized as a biodiversity hotspot but its centre is only approximately located and its exact boundaries are unknown (Fig. 3). Some researchers believe that the western angle of the triangle may reach the coast of Vietnam or Peninsular Malaysia, or both; at least, the biodiversity hotspot usually includes the southern half of the South China Sea (Fig. 3). Although many molluscan taxa show maximum diversity in the Indo-Malayan region, differences in the Indo-West Pacific distribution maxima show that there is a clear dependency on habitat diversity. The diversity patterns of reef-dwelling molluscs may differ from those of mangrove-associated molluscs, whereas others taxa may occur in both kinds of environments; many molluscan taxa are found on coral reefs (Hoeksema, 2007).

The effect of sampling effort on species richness has been demonstrated by Bouchet et al. (2002). A massive collecting effort involving 400 day-persons at 42 discrete stations on a 295-km² site on the west coast of New Caledonia, south-west Pacific, revealed 2738 species of marine molluscs. This was several times higher than the number of species recorded from any area of comparable size anywhere in the world. With 20% of the species represented by single specimens (0.4% of all catches), rare species make up a considerable proportion of the fauna. Another example is the Panglao Marine Biodiversity Project carried out in 2004 to document the fauna and measure species richness of an ecologically complex coastal site in the central Philippines; the area surveyed covered about 150 km². Compared to the New Caledonia site that had been sampled with the same approach, the Philippines site is 40% to 540% richer in species. Preliminary estimates suggest that between 5000–6000 species of mollusks were sampled (Bouchet et al., 2009), or the Panglao site can be estimated to have somewhere between 4000 and 14,000

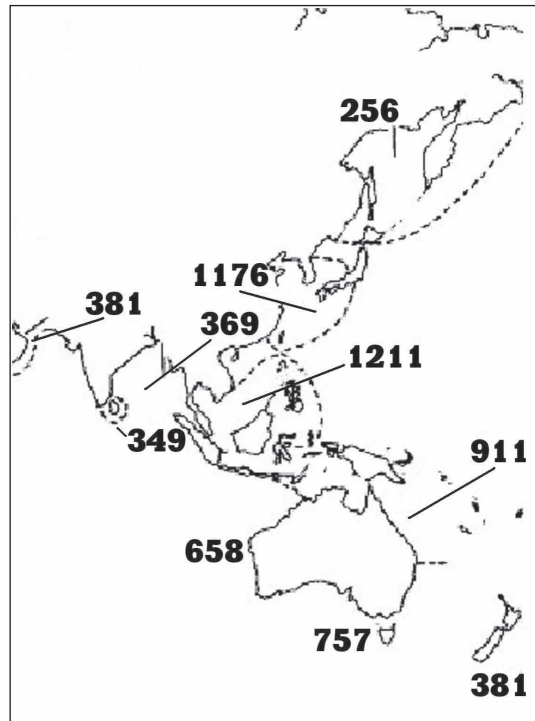


Fig. 2. Species richness (number of species) of bivalve mollusks in the south-east Asia and adjacent some areas (modified and re-drawn after Crame, 2000).

species of molluscs (Bouchet, 2009). In Espiritu Santo (Vanuatu), about 4000 morphospecies of mollusks were recorded through intensive collecting (Bouchet et al., 2011). These examples shows that the overall biodiversity of mollusks in the western South China Sea is underestimated and, with modern sampling techniques and

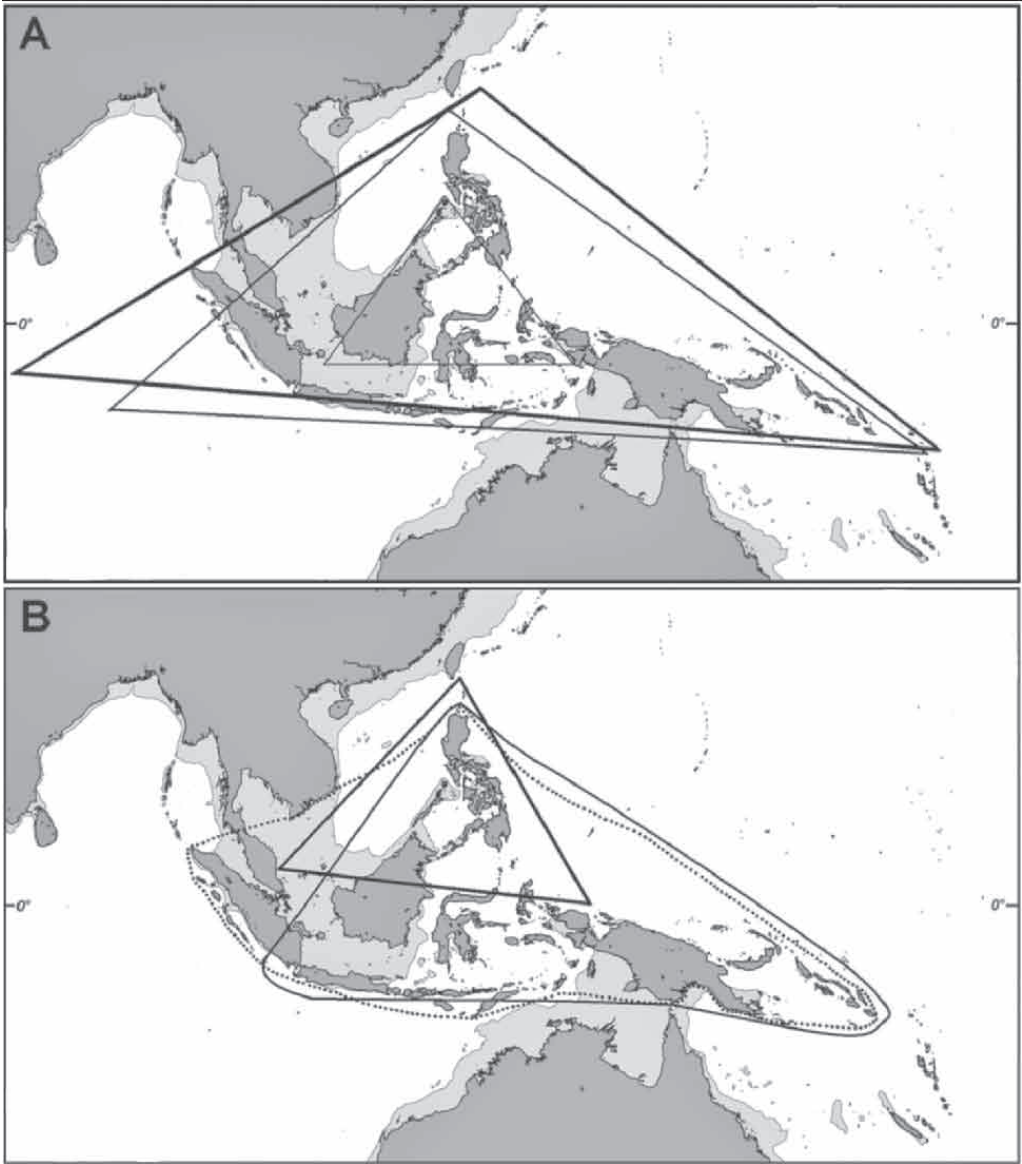


Fig. 3. Various versions of boundaries of the Coral Triangle (Indo-Malayan centre of marine biodiversity) (re-drawn after Hoeksema, 2007).

approaches, this would be increased significantly in the future, taking into account the proximity of the region to the Coral Triangle.

Regional differences in species richness of bivalves in the South China Sea are not clear. Present-day data mainly reflect sampling effort and the state of the knowledge of this fauna rather than real discrepancies between faunas (Table 2). Based on available data, we may assume that the richest faunas of bivalve mollusks are those of Vietnam (more than 815 species) and the Chinese part of the South China Sea (822 species) (Fig. 4). Peninsular Malaysia and Singapore bivalve faunas ranging from 206 to 344 are underestimated and obviously richer. Another biodiversity hot

Table 2

Species richness of bivalve mollusks in various parts of the western South China Sea

Region	Number of species	Reference	Comments/notes
Singapore	344	Tan, Woo (2010)	Majority of existing literature records cannot be verified due to a lack of voucher specimens
Malaysia and Singapore	186	Morris, Purchon (1981)	Including records from western coast of Peninsular Malaysia
Malaysia	206	Wong, Arshad (2011)	Peninsular Malaysia and East Malaysia (Malaysian Borneo)
Thailand	153	Suvatti (1938)	Including western Thailand; excluding species of Corbiculidae
Gulf of Thailand	336	Lynge (1909)	Samples only from the northern and eastern parts of the Gulf of Thailand, and only down to a depth of about 35 fathoms (64 m)
Southern Gulf of Thailand	229	Swennen et al. (2001)	The area roughly between 6° and 7° N, about 10.000 km ²
Northern and western Gulf of Thailand	271	Robba et al. (2002, 2003, 2007)	Records include Holocene shells recovered from the Holocene Bangkok Clay; Phetchaburi area; Pak Phanang Bay
Eastern coast of the Gulf of Thailand	321	Sampanich (2011)	From the Province of Chonburi to Trad (55 sampling sites)

Table 2 (Continued)

Region	Number of species	Reference	Comments/notes
Gulf of Thailand	594	Jensen (2004)	Species list is not provided; estimate is based on literature data
Cambodia	93	Fischer (1973)	Excluding Corbiculidae
Cambodia	79	Jensen (2004)	Species list is not provided; surveys in 1999–2001
Vietnam	176	Fischer (1987)	Based on French collections and published papers
Vietnam	320	Cai, Li (2002)	Based on Chinese collections
Vietnam	367	Lutaenko (2000b)	Based mostly on voucher specimens from two largest Russian collections of mollusks
Vietnam	815	Hylleberg, Kilburn (2003)	A compilation of all data available for Vietnam (literature and voucher collections in Vietnam)
Binh Cang – Nha Trang Bay (central–southern Vietnam)	95	Nguyen Van Chung, Huynh Minh Sang (2004)	Based on six surveys
Khanh Hoa Province (central–southern Vietnam)	267	Bui Quang Nghi (2001)	
Tonkin Gulf (Beibu Gulf)	351	Zorina (1975, 1978a, b)	Based on Russian collections (Zoological Institute, Russian Academy of Sciences)
Tonkin Gulf (Beibu Gulf)	368	Do Cong Thung, Le Thi Thuy (2007); Do Cong Tung et al. (2013)	
Tonkin Gulf (Beibu Gulf)	352	Nguyen Xuan Duc (2003)	
Cat Ba Islands and Ha Long Bay	173	Nguyen Xuan Duc (2001)	
Guangdong Province, China	401	Cai, He (2006)	

Table 2 (Continued)

Region	Number of species	Reference	Comments/notes
Hong Kong, southern China	299	Valentich-Scott 2003); Lutaenko, Volvenko (2013)	
Chinese part of the South China Sea	822	Xu, Zhang (2011)	Based mostly on the collection of the Institute of Oceanology, Chinese Academy of Sciences (Marine Biological Museum)

spot is the Gulf of Thailand with nearly 600 species of bivalves, and Tonkin Gulf (351–368 species) and Hong Kong (nearly 300 species) should also be mentioned (Table 2; Fig. 4). Biodiversity must show an increase from north to south, the “latitudinal gradient”, widely known in biogeography, which demonstrates a negative relationship between latitude and species diversity (Briggs, 1995); however, insufficient faunal data for the southwestern South China Sea do not allow this pattern to be traced.

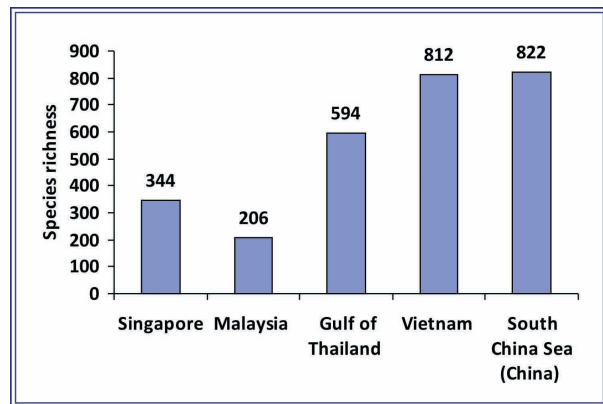


Fig. 4. Species richness of bivalve mollusks in major regions of the western South China Sea (Singapore, Malaysia, the Gulf of Thailand, Vietnam and Chinese (mainland) part of the South China Sea).

Biogeography

Biogeographically, the major part of the South China Sea belongs to the *tropical Indo-Polynesian Province* (Briggs, 1974, 1995). This province extends all the way from the entrance to the Persian Gulf to the Tuamotu Archipelago, and from Sandy Cape on the coast of eastern Australia to the Amami Islands in southern Japan; all of Polynesia is included with exception of the Hawaiian Islands, the Marquesas, and Easter Island (l.c.). In turn, the Indo-Polynesian Province is a part of the Tropical Indo-West Pacific Region, along with the Western Indian

Ocean, Red Sea, Hawaiian, Marquesas, and Easter Island provinces (Briggs, 1995; Briggs, Bowen, 2012). However, the northern mainland part of the South China Sea belongs instead to the *warm-temperate* **Sino-Japanese Province** extending from Cape Inubo on the oceanic side of Japan southwards to, but not including, the Amami Islands, and on the mainland side, it begins at the tip of the Korean Peninsula and at Hamada, Honshu, in the southern part of the Sea of Japan; on the Chinese coast, it begins at about Wenchou and extends southwards to Hong Kong (Briggs, Bowen, 2012). The northwestern coast of Taiwan exhibits an affinity with the warm-temperate mainland coast, while the southeastern coast is purely tropical, being under the influence of the Kuroshio Current (Briggs, Bowen, 2012). This biogeographic unit was known previously as the **Japan Warm-Temperate Region** (Briggs, 1974, 1995) (Fig. 5).

According to our concept, the *subtropical* **Sino-Japanese Province**² occupies the southern part of the Sea of Japan and extends into the Yellow Sea, including southern Japan, the East China Sea (Lutaenko, Noseworthy, 2014a, b), and, according to Briggs (l.c.), to the northern South China Sea. The status of the Yellow Sea deserves special attention. The Sino-Japanese Province belongs to the tropical Indo-Pacific fauna, as was originally advocated by Gurjanova (1972a). A majority of the bivalves living in the Yellow Sea are subtropical species; many truly tropical species are present, and the fauna of the sea has a close affinity to southern Japan (Gurjanova, 1972; Kafanov, 1991; Lutaenko, Noseworthy, 2014a). Chinese and western biogeographers (Liu, Hsu, 1963; Tchang et al., 1963; Briggs, 1974, 1995; Spalding et al., 2007; Briggs, Bowen, 2012; Liu, 2013, 2014) regard the Yellow Sea as belonging to the cold-temperate fauna; however, Gurjanova (1961, 1972a) believes that the Yellow Sea fauna is a part of the tropical Indo-Pacific region and its subtropical sub-region, and this view is here accepted. However, this fauna is impoverished because of the shallowness of the sea, the influence of deep cold-water masses, and severe winter cooling which conceal its subtropical character. Zhang and Xu (2014) think that the Yellow and Bohai seas are dominated by warm-water bivalve mollusks, and the intertidal zone and coastal areas of these seas can be regarded as a part of the Indo-Pacific Warm Region while, in contrast, the deeper part of the Yellow Sea should be considered as a part of the Northern Pacific Temperate Region.

² The use of the term “subtropical” appears to be more appropriate, as subtropical species in their origin are related to the tropical, but not the boreal (=temperate), fauna. Briggs (1995) clearly stated that the warm-temperate regions border the tropics and have evident tropical relationship whereas the cold-temperate (=boreal) regions have biotas that are markedly different from those of the warm-temperate (subtropical) regions. The term “warm-temperate” of American workers should correspond to “subtropical” (Kussakin, 1990; Lutaenko, Noseworthy, 2014a).

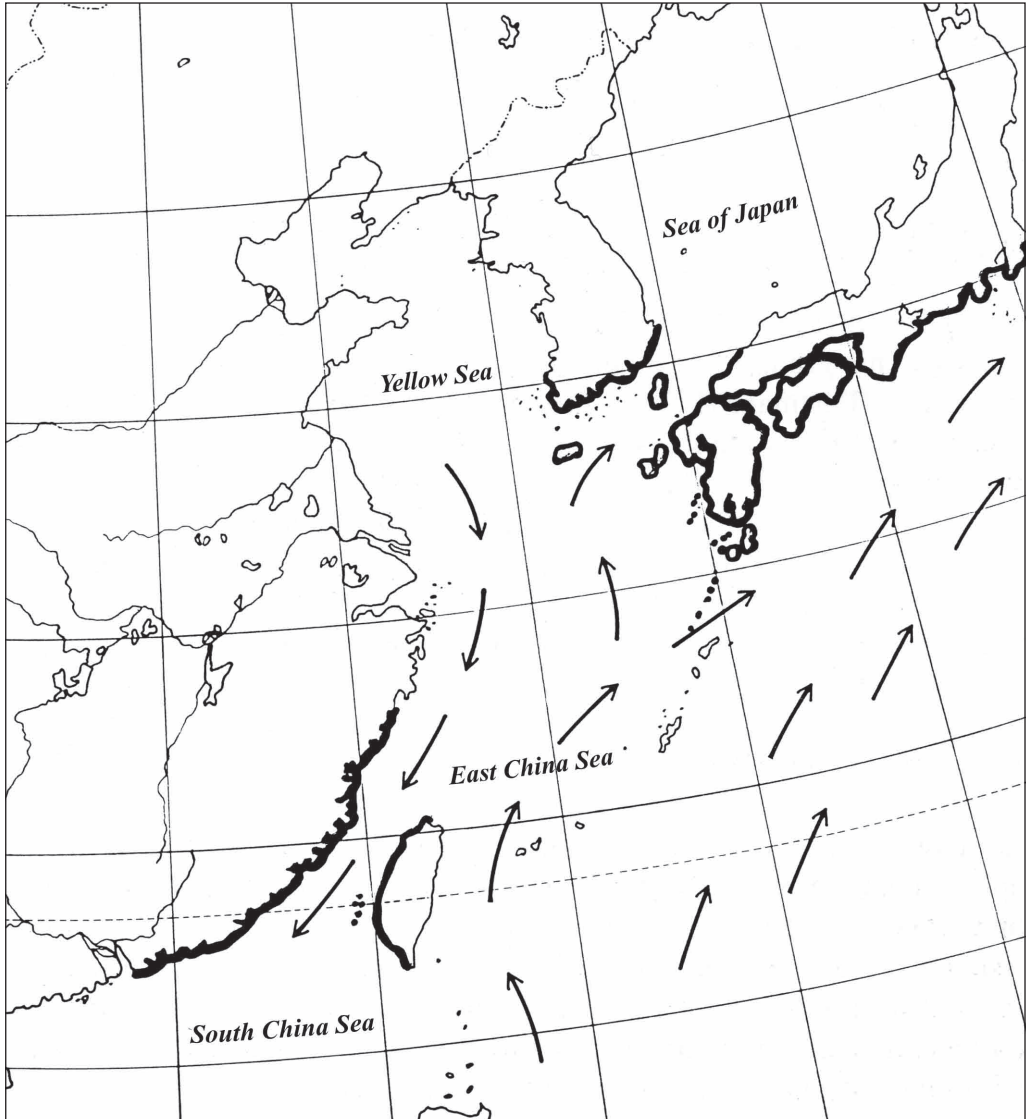


Fig. 5. Japan Warm-Temperate Region (re-drawn after Briggs, 1995). Note that its southern part lies along the mainland coast of China (Wenchou – Hong Kong) and on the west coast of Taiwan; later called Sino-Japanese Province (Briggs, Bowen, 2012).

According to Liu (2013, 2014), the boundary between the tropical-subtropical biotic region and the warm-temperate biotic region extends roughly from the Yangtze River Estuary eastward to Niigata, northern Honshu, Japan, and north to Jeju Island and the Korea Strait. The boundary between the China-Japan Subtropical Subre-

gion and the Tropical Southern South China Sea Subregion extends roughly from mid- or southern Vietnam to Amami Oshima Island, north of Okinawa, Japan, through the southernmost sea area off Hainan Island and the southeast coast of Taiwan (Fig. 6). Liu (l.c.) states that his “China-Japan Subtropical Subregion” (=Sino-Japanese Province) belongs to the Indo-Pacific tropical fauna (“the Indo-West Pacific Warm-Water Biotic Region”), and this view is here accepted. However, its southern limits lie northward in Guandong Province and not in mid-Vietnam: the Vietnamese biota could hardly be subtropical. Malyutin and Latypov (1991) clearly showed that the coral fauna of Vietnam, including Gulf of Tonkin, is represented solely by tropical species. It is noteworthy that Chinese workers use the terms “subtropical” and “warm-temperate” for different faunas: the Yellow Sea fauna is warm-temperate, but the East China Sea fauna is subtropical. Here they are regarded as synonymous.

Thus, the western part of the South China Sea is divided between two provinces: the truly tropical, vast Indo-Polynesian Province and the subtropical Sino-Japanese Province, and the boundary line lies around Hong Kong. Gurjanova (1961, 1972a) demarcated the Asian coast into several biogeographic units within the Indo-West Pacific tropical region, from north to south: **1**, Yellow Sea Province; **2**, South-Japanese Province; **3**, Hainan Province; and **4**, Malayan Province (Fig. 7). It is easy to observe that the northern boundary of Hainan Province nearly corresponds to the northern boundary of Briggs’ southern part of the Sino-Japanese Province. However, the meaning and content of provinces in Russian and western literature are different. Briggs’s (1974) provinces were defined on the basis of endemism: a value of 10% was chosen for an area to qualify as a distinct province (Briggs, 1974). According to Gurjanova (1972a), the Hainan Province extends south to Tonkin Gulf or even to Cape Varella in Vietnam (Mui Ke Ga, 12° N), and its fauna is close to that of the Malay Archipelago but is much poorer. Malyutin and Latypov (1991), based on the coral fauna, regard the entire Vietnamese coast as biogeographically uniform, and do not support its demarcation into any units and do not recognize any biogeographical lines or boundaries within Vietnam.

The position of the Hong Kong fauna in biogeographical zonation is intermediate. Winter cooling by north-east monsoonal winds, the presence of the winter period from October to mid-March with a minimum air temperature of 15°C in February, and the warm summer with an average July temperature of 28°C allow the climate and the hydrology of Hong Kong to be regarded as subtropical (Morton, Morton, 1983). The waters of Hong Kong are rich in tropical biota but, at the same time in the winter period, temperate algae are found in abundance. Mangroves flourish with near tropical diversity but are dwarfs in comparison with their Malaysian relatives; corals are also well represented but only in the subtidal zone because



Fig. 6. Zonation of the zoobenthic fauna of the China seas: **1**, the North Pacific Temperate Biotic Region, Far Eastern Cold-Temperate Subregion; **2**, the North Pacific Temperate Biotic Region, East Asia Warm-Temperate Subregion; **3**, the Indo-West Pacific Warm-Water Biotic Region, China-Japan Subtropical Subregion; **4**, the Indo-West Pacific Warm-Water Biotic Region, Indo-Malaysian Tropical Subregion (re-drawn after Liu, 2013).

of the low winter air temperatures (l.c.). The surface temperature of the water in Victoria Harbor falls in winter to 16–17°C, while in the summer it approaches 27–28°C; however, at the bottom layer it reaches only to about 24–26°C. The Taiwan Current brings the biota of the subtropical coasts of northern China and southern Japan while the Hainan Current contributes truly tropical species (Morton, 1983). Adjacent to Hong Kong, the Daya Bay molluscan fauna comprises a mixture of tropical and subtropical species living in both South China and East China seas (Lin et al., 2002).

Based on the distribution of sacoglossan opisthobranchs, Jensen (2006) believes that the vast Indo-Polynesian Province can be subdivided into five sub-provinces: **1**, a subprovince of the Indian subcontinent, including Sri Lanka and the Maldives; **2**, the Andaman Sea, the South China Sea, Indonesia and the Philippines form an Indo-Malayan subprovince; **3**, the Mariana and Marshall Islands together with Micronesia are considered a Central Pacific sub-province; **4**, Papua New Guinea, Solomon Islands, Fiji, Vanuatu, New Caledonia, Samoa, and the Polynesian islands form a South Pacific sub-province; and **5**, the Ryukyu Islands form a separate sub-province. This wide understanding of the Indo-Malayan

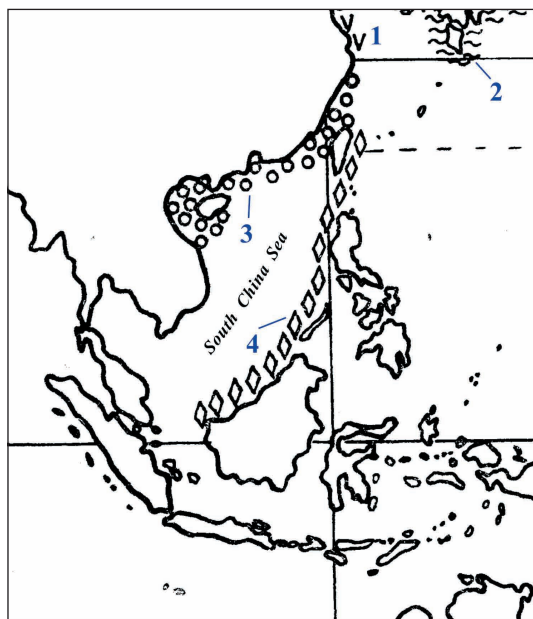


Fig. 7. Biogeographical provinces belonging the Indo-Pacific tropical region along the Pacific coast of Asia: **1**, Yellow Sea Province; **2**, South-Japanese Province; **3**, Hainan Province; and **4**, Malayan Province (re-drawn after Gurjanova, 1972a).

Province nearly corresponds to one of the variants of the Coral Triangle. We believe that the South China Sea molluscan fauna may belong to two biogeographical units as its western and eastern parts are not equal in terms of species richness and the western part obviously has more Sino-Japanese elements.

Perhaps a good example for understanding the biogeographical differences within the South China Sea is the Vietnamese bivalve fauna. The Vietnam coast has a north-south orientation of more than 1650 km, and is situated along the southeastern margin of the Indochinese Peninsula, an area from 23° N to 8°30' N. No detailed analysis of the biodiversity and biogeography has been published for the entire Vietnamese marine bivalve fauna; hence, some

older papers are reviewed in order to draw attention to problems to be dealt with in the future based on more comprehensive faunal data.

Gurjanova (1972b) showed that the fauna of Tonkin Gulf, situated in the tropical zone, bears typical tropical features, but it is impoverished due to “subtropical” conditions, i.e., pronounced seasonality and winter cooling of the water masses down to the seafloor. These “negative features” of the Tonkin Gulf fauna were illustrated using the example of bivalve mollusks (Gurjanova, 1972b), and can be summarized as follows:

1. Absence of some common tropical faunal elements in the Tonkin Gulf fauna. *Mytilus smaragdinus* Gmelin, 1791 (= *Perna viridis* (L., 1758)) (Mytilidae) was not found in the Gulf’s fauna, whereas it is a commercially important and abundant species in the Gulf of Thailand and southern Vietnam. Three species of the genus *Tridacna*, typical Indo-West Pacific bivalves of the family Tridacnidae, were collected only on the southern coast of Hainan Island, but not on the Vietnamese coast, and the genus *Hippopus* is completely absent even in the Hainan fauna. According to Liu (2014), the southern and southernmost waters of Hainan Island are inhabited by six tridacnid species. Because of the poor development of coral reefs, only a few species of coral borers were found, and the impoverished composition of the genera *Chama* (Chamidae), *Spondylus* (Spondylidae) and Ostreidae was detected. For instance, among ostreids, only five species occur on the Vietnamese coast, while at Hainan Island there are 17 species. Gurjanova (1972b) also noted the rare occurrence of *Chlamys* and *Pecten* (Pectinidae) on the Vietnamese side of the gulf. Liu (2014) noted that some typical stenothermic animals have not been found in Hainan, and that Hainan is really at the edge of the tropical biotic region.

2. Difference between the fauna of southern Vietnam and Tonkin Gulf. About 170 species of Bivalvia were recorded for southern Vietnam based on different sources and only 101 species for Tonkin Gulf (Gurjanova, 1972b, p. 89). The same trait was established for gastropods. Gurjanova (1972b) explained the impoverished character of the Tonkin Gulf fauna by the strong variability of hydrological factors and water mass dynamics caused by a complicated and unstable circulation system with strong tidal currents. However, Latypov (2000) found that the reefs of the northern part of the Bai Tu Long Archipelago and Ha Long and Bai Tu Long bays, in Tonkin Gulf, show a great degree of similarity in composition and distribution of reef-building corals with other reefs of Vietnam and the whole South China Sea, having from 60% to 72% of the scleractinian species in common, and a rather great species diversity; no less than one third of the common coral species of the Pacific fauna are found here (Latypov, 2000). In light of new faunal data available from Vietnamese literature, the differences between southern and northern Vietnam molluscan faunas should be re-assessed.

Six types of distributional ranges of bottom fauna species inhabiting Tonkin Gulf were recognized, with emphasis on bivalve species (Gurjanova, 1972b):

1. Pan-Indo-Pacific species widely distributed from the eastern coast of Africa eastward to islands of the central part of the Pacific Ocean, northward to southern Japan and southward to Australia;

2. Eastern elements, or Philippine-Malayan West-Pacific species distributed in the western tropical Pacific Ocean, with the center of their development being the shallow waters of the Malayan Archipelago and the Philippine Islands;

3. Eastern Atlantic-Indian elements, or species distributed in the Indian Ocean, or Indian and Atlantic Oceans, and spreading eastward to Indo-China and the Malayan Archipelago;

4. Sino-Japanese elements, or species distributed from southern Japan and along the continental coast of China southward to the eastern continental shelf of Indo-China;

5. Atlantic-Mediterranean elements are recognized based on polychaete fauna with reference to possible existence of such ranges in mollusks;

6. Sino-Vietnamese elements, or species distributed in the north-western part of the South China Sea (Hainan Island and Guangdong Province) and Tonkin Gulf; here the only possible endemic Vietnamese species is known, *Isocardia vulgaris* Reeve, 1845 (= *Meiocardia vulgaris* (Reeve, 1845)), in the Glossidae.

Based on the analysis of distributional ranges of bottom fauna species, Gurjanova (1972b), in her biogeographical scheme, placed Tonkin Gulf in the “Hainan Province of the Sino-Japanese Subregion of the West-Pacific Region of the Indo-West Pacific Superregion”.

Based on the species compositions of the families Donacidae, Veneridae, Mactridae, Psammobiidae, Tellinidae, Solecurtidae, and Semelidae (140 species), Zorina (1975) subdivided the Tonkin Gulf fauna into ten biogeographical groups (Table 3).

Separate analysis of the fauna of the intertidal zone, 74 species, and subtidal zone, 66 species, showed that the species compositions of both zones are close to each other in biogeographical characteristics; however, some differences between these bathymetric areas are found. Among subtidal inhabitants, species widely distributed in the Indo-Pacific in its eastern part or in the western Pacific Ocean are predominant (61%), while only 49% of the intertidal fauna has such distributional ranges. Among intertidal species, the share of mollusks whose distribution is limited by the coasts of China and Japan is higher (16%) as compared to the subtidal fauna (10%). Zorina (1975) stated that there is no sharp difference in biogeographical composition of the intertidal and subtidal faunas because of the absence of purely

Table 3

Biogeographical analysis of Tonkin Gulf bivalve molluscan fauna based on seven families (Donacidae, Veneridae, Mactridae, Psammobiidae, Tellinidae, Solecurtidae and Semelidae) (after Zorina, 1975)

Biogeographical group	Number of species
1. Indo-West Pacific species in the broadest sense	20 (14.3%)
2. Indo-West Pacific species (without Oceania)	29 (20.7%)
3. Indo-West Pacific species with disjunct distributional ranges	8 (5.7%)
4. West-Indian - Western Pacific species	16 (11.5%)
5. West Pacific (including Oceania) species	3 (2.2%)
6. Japanese-Malayan species	15 (10.7%)
7. Philippine-Malayan species	10 (7.1%)
8. Chinese-Australian species	14 (10%)
9. Chinese-Japanese species	19 (13.5%)
10. Possible endemics of Tonkin Gulf	6 (4.3%)

intertidal genera and the significant role of planktonic larvae in the dispersal of bivalve mollusks. A biogeographical analysis of the entire fauna of Tonkin Gulf and Hainan Island led to the conclusion concerning the predominance of tropical species (132, or 94%), that the distributional ranges of these species lie exclusively in tropical waters. Seven species (5.3%) reach to southern Japan and the Yellow Sea, and, thus, can be regarded as tropical-subtropical, and one species (0.7%), *Mactra quadrangularis* Deshayes in Reeve, 1854 (Mactridae), penetrates also into the low-boreal (temperate) area of the Sea of Japan in its north-western part. Seventy-three species (or 52.1%) of the Tonkin Gulf bivalve fauna are known from the Indian Ocean.

Comparison of the Tonkin Gulf fauna with those of the Philippine Islands and Japan showed that the former one is 2.5 times poorer than the Philippine fauna, but, at least, 1.3 times richer than the Japanese fauna. There is a great difference between the intertidal faunas of the continental and Hainan Island coasts of Tonkin Gulf; the Hainan Island fauna is twice as rich in species. Therefore, Zorina (1975) confirmed the conclusion of Gurjanova (1972b) concerning the impoverished character of the Tonkin Gulf fauna caused by the specific hydrological

regime, namely low winter temperatures and high seasonality. Nguyen Van Chung and Dao Tan Ho (1995) established that the number of zoobenthic species found in Tonkin Gulf is about 20% of the total Vietnamese fauna, and the diversity of species increases from north to south showing a latitudinal gradient.

It should be noted that a biogeographical analysis performed on the basis of 351 species identified by Zorina (1978a) yielded different figures (Table 4), especially concerning the share of typical tropical species (45.9%), which is much lower as compared to the results of analysis of the seven selected families (94%).

In general, the fauna of the South China Sea contains, in various proportions in different parts of the region, the following zonal-geographical groups: tropical, tropical-subtropical, tropical-subtropical penetrating to boreal (temperate, or mild-temperate) waters, and subtropical. In the north, Taiwan, Fujian and northern Guangdong provinces, the presence of subtropical and subtropical-lowboreal species is noteworthy. The Atlantic element is represented by an alien mussel, *Mytilus galloprovincialis* Lamarck, 1819 (Mytilidae) (Lee, Morton, 1985; Morton, 1987). Some, mostly common, species of bivalves of the South China Sea are figured on Plates 1–21.

Table 4

Zonal-geographical (A) and biogeographical (B) analyses of Tonkin Gulf fauna of bivalve mollusks based on 351 species (after Zorina, 1978a)

A		
Tropical species	161 species	45.9%
Tropical-subtropical species	190 species	54.1%
B		
Circumtropical species	7 species	2.2%
Widely distributed Indo-West-Pacific species	143 species	40.8%
Species distributed in the eastern part of the Indo-Pacific and penetrating as far westward as Bay of Bengal	144 species	41%
Species distributed in China and Japan	42 species	11.8%
Possible endemics of Tonkin Gulf	15 species	4.2%

Problems in the study of molluscan biodiversity

One of the great scientific problem in tropical taxonomic malacology is a hypertrophied and oversaturated synonymy. Mollusks are usually large and attractive animals that have gathered the most interest from travellers, collectors, and scientists, and it is believed that every named species of mollusk may have had four to five names, with an accumulated load of perhaps 300,000 names (Bouchet, 2006). Other workers believe that the Mollusca are among the taxa with a synonymy rate of over 50% (Appeltans et al., 2012). Old synonyms are copied from one color catalogue or guidebook to another without critical examination of existing literature, type material, and consultations with taxonomists. In the absence of serious revisions for many groups, and the decline of the taxonomic community in the second half of the twentieth century, our biodiversity knowledge seems, in some ways, to be false and impoverished. Even with modern analytical tools and approaches, synonyms represent at most 10–20% of the new species currently being described each year (Bouchet, 2006). However, frequent misidentifications and underestimation of biodiversity have serious consequences when marine areas need to be studied, assessed, and conserved (Ng, Tan, 2000) and, taking into account the high diversity and wide distribution of bivalves in the South China Sea, the problem of misidentification and poor taxonomic knowledge is extremely important. A lot of regional faunal data, especially those for Vietnam, Singapore, and Malaysia, are not based on voucher collections of mollusks but mostly are outdated published identifications or non-professional records. Ecological and environmental assessments become useless if we do not know well the species we deal with in marine ecosystems and communities.

A related problem is a lack of taxonomic expertise with mollusks in many countries surrounding the South China Sea. There are few professional malacologists trained in taxonomy, and there are few well-curated research collections/museums with voucher specimens. Few young scientists want to devote themselves to traditional taxonomy due to limited financial support and low prestige of this field of biology. Other challenges confronting biodiversity specialists in the region include lack of literature, difficulties in disseminating data, and general lack of governmental commitment to develop biodiversity research to its full potential (Ng, 2000). The best collections from the South China Sea, besides Europe, the U.S.A., and Russia, are in the Institute of Oceanology, Chinese Academy of Sciences, Qingdao, the Lee Kong Chian Natural History Museum, National University of Singapore, formerly the Raffles Museum of Biodiversity Research, the Bogor Museum in Indonesia, and the National Museum of the Philippines, which oversees also the National Museum of Zoology; in recent years lack of finances, trained manpower, space, equipment, and coordination has seriously hindered biodiversity research at the latter institution

(Ng, 2000). There are no national museums in Malaysia, Vietnam, and Cambodia although regional collections in universities and some research institutes play an important roles. The most effective means of upgrading the value and scientific importance of regional museums is the development of a strong research program, regular publishing, commitment to academic meritocracy, and globalisation of biodiversity information (Ng, 2000).

Wong and Arshad (2011) state that there is an urgent need in Malaysia for a depository centre with sufficient space, facilities for curators, and a need for well-trained taxonomists; the taxonomic studies there started only in the 1970s with the establishment of local universities; however, marine mollusk taxonomy has never become the centre of interest in any of the present universities. The lack of funding in supporting taxonomic studies is another factor that limits the proliferation of malacology (Wong, Arshad, 2011). There are many marine parks and protected areas in Malaysia but detailed molluscan biodiversity data for them are not available.

Kilburn (1997) regarded the situation concerning molluscan diversity in the “Malesian” region as the “biodiversity crisis” which can be summed up as the following: **1**, the known and estimated diversity is vast; **2**, taxonomic data are inadequate; **3**, the number of practicing taxonomists is small and diminishing; **4**, habitat degradation is escalating.

A check-list, combining both literature and voucher specimens, of bivalves of the western part of the South China Sea is needed, and regional, site-based faunal studies are urgently desirable.

Unfortunately, as we have observed for the last 30 years, research policies ensuing from the Convention on Biological Diversity (CBD) made huge funds available to study biodiversity but these were mostly dedicated to projects aimed at providing services to taxonomy via information and technology, or to develop molecular approaches to taxonomy while traditional taxonomy was overly neglected, and is in serious distress all over the world (Boero, 2010). We are losing the rich biodiversity of the South China Sea, an overpopulated and heavily human-impacted ecosystem, without knowing what has lived in the sea, and the rate of progress in inventorying the molluscan diversity of the South China Sea is very low.

Threats to molluscan biodiversity

Threats to marine biodiversity, including molluscan faunas, in the South China Sea are habitat degradation, fragmentation and loss – especially mangrove forest destruction, loss of coral reefs, change in the landscape mosaic of wetland, estuary, and sand and mud flats; global climate change including sea level rise, storm events, rainfall pattern changes, and warming of the coastal ocean; effects of fishing

and other forms of overexploitation, pollution and marine litter; species introduction/invasions, physical alterations of coasts, and tourism (Gray, 1997; Chen, Chen, 2002; Liu, 2014; Lutaenko, Thái, 2014; and others).

Continued warming through the twenty-first century is inevitable and will likely have widespread ecological impacts (Serreze, 2009). In Vietnam, the Red (Song Hong) and Mekong rivers discharge into the sea, and the drainage systems of these two transboundary rivers cover parts of six countries, and their water and sediment discharges greatly influence the coastal seas of Vietnam. The impact of human activity includes changes in the quality of the coastal and marine environments due to the increased use and accumulation of pollutants, and the loss of habitat. These impacts have resulted in the increasing unpredictability and severity of coastal problems, such as floods, erosion, sedimentation, saltwater intrusion, environmental pollution, and the degradation of ecosystems, with an accompanying decrease in biodiversity and fishery productivity (Tran Duc Thanh et al., 2004).

Bivalve mollusks play an important role in the fishery industry of Vietnam; at least 28 species (*Anadara granosa* (L., 1758), *A. antiquata* (L., 1758), *Arca navicularis* Bruguière, 1789, *Perna viridis* (L., 1758), *Modiolus philippinarum* (Hanley, 1843), *Amusium pleuronectes* (L., 1758), *Chlamys nobilis* (Reeve, 1852), *Ostrea rivularis* Gould, 1861, *Pinctada martensii* (Dunker, 1872), *P. maxima* (Jameson, 1901), *P. margaritifera* (L., 1758), *Pteria penguin* (Röding, 1798), *Pinna vexillum* Born, 1778, *Cyrenobatissa subsulcata* (Clessin, 1878), *Cyrena sumatrensis* Lea, 1832, *Lucina philippinarum* Reeve, 1850, *Tridacna squamosa* Lamarck, 1819, *Dosinia laminata* (Reeve, 1850), *Cyclina sinensis* (Gmelin, 1791), *Meretrix meretrix* (L., 1758), *M. lyrata* (Sowerby II, 1851), *Katelsysia rimularis* (Lamarck, 1818), *Anomalocardia squamosa* (L., 1758), *A. flexuosa* (L., 1767), *Mactra quadrangularis* Deshayes in Reeve, 1854, *Sanguinolaria diphos* (L., 1771), *Glaucone chinensis* Gray, 1828, and *Potamocorbula laevis* (Hinds, 1843)) are regarded as having high economic value (Nguyen Chinh, 1980, 1999a; Nguyen Huu Phung, Vo Si Tuan, 1996). (All species names are given in their original nomenclature; some are currently synonyms). The most commercially important species are *A. antiquata*, *A. granosa*, *M. lyrata* and *C. nobilis*; there are plans to culture *M. lyrata* and *A. granosa* (Vo Si Tuan, Nguyen, 1998). *A. granosa* (“krang”) is the most important edible species in Malaysia and Singapore (Purchon, Purchon, 1981). *Orbicularia orbiculata* (Wood, 1828), *Pharella javanica* (Lamarck, 1818), *Cultellus lacteus* (Spengler, 1794), *Psammotellina tenuis* (da Costa, 1778), *Coecella horsfieldii* (Gray, 1853), and others are distributed in Malayan and Singaporean markets (l.c.).

In Thailand markets, 31 bivalves were collected, and among them the green mussel *P. viridis*, the blood cockle *A. granosa*, and the short-necked clam *Paphia undulata* (Born, 1778) were economically very important and found in all markets;

oysters and a shipworm, *Bactronophorus thoracites* (Gould, 1856) (Teredinidae) were sold at high prices (Amornjaruchit, 1988; Nateewathana, 1995). It is obvious that the harvesting of bivalves has continued for centuries in the basin of the South China Sea as mollusks play an important role in the diet of Asian people, and one can imagine the increase of human pressure on the molluscan resources due to population growth.

According to Di Geronimo et al. (2005), in the northern Gulf of Thailand the living associations of mollusks obtained at the same locations appear to be markedly depleted in both species richness and total number of specimens, if compared to the co-occurring thanatofacies. The whole seabed area studied has undergone a dramatic negative change in benthic molluscan biodiversity during the last decades, and this change seems to be related primarily to the intensive trawling in shallow water practiced by local coastal villagers; other causative agents are likely shrimp farming effluent and sewage from coastal settlements that affect water quality.

An interesting example of the decline of a tropical molluscan fauna is provided by Jakarta Bay (West Java, Indonesia). In 1937/1938 representative mollusk collections were made in the bay, and new data from here and the adjacent off-shore Thousand Islands archipelago (Kepulauan Seribu) became available in 2005. A comparison of the molluscan fauna between the 1930s and 2005 reveals a distinct deterioration. Jakarta Bay contained 171 species of mollusks in 1937/1938, compared to 58 species in 2005 and, from a total of 70 genera, 16 genera (23%) disappeared (Meij et al., 2009). In the twentieth century, Jakarta Bay received increasing amounts of sewage from the greater Jakarta area, as well as increased sediment input from the deforested West Java hinterland. Predatory gastropods and numerous mollusc species associated with carbonate (reef) substrate have vanished from Jakarta Bay, among them many edible species (Meij et al., 2009).

Cambodia's marine ecosystems, including biodiversity-rich coral reefs, seagrass beds, and mangroves are under increasing pressure from unsustainable fishing practices, sedimentation, coastal development, and marine-based pollution; ninety percent of the coral reefs in Cambodia are estimated to be under high level of risk and the overall trend is increasing overexploitation of the coastal zone (Boon et al., 2014). Meanwhile, the molluscan diversity of the Cambodian coastal waters is poorly known and based only on old French studies. A total of 21 bivalve species are used by people in Cambodia (*A. granosa*, *Anadara nodifera* (Martens, 1860), *Anadara binakayanensis* (Faustino, 1932), *A. cf. inaequivalvis* (Bruguière, 1789), *Anadara uropigimelana* (Bory, 1824), *Barbatia foliata* (Forsskål, 1775), *P. viridis*, *Atrina vexillum* (Born, 1778), *Crassostrea belcheri* (Sowerby, 1871), *Vepricardium sinense* (Sowerby, 1841), *T. squamosa*, *Soletellina cumingiana* Reeve, 1857, *Asaphis violascens* (Forsskål, 1775), *Polymesoda erosa* (Solander, 1786), *Gafrarium tumidum* (Röding, 1798), *Pelecypora cf.*

trigona (Reeve, 1850), *Anomalocardia squamosa* (L., 1758), *Paphia undulata* (Born, 1778), *Meretrix* sp., *M. lyrata*, *Periglypta* cf. *clathrata* (Deshayes, 1854)). Among them, 19 species are sold in markets for food, and two bivalves are collected mainly for their shells and sold in the shell shops for ornaments (Ing, 2001).

Current threats to the marine biodiversity of Malaysia include removal of mangrove forest ecosystems, increased commercial fisheries, destruction of coral reef ecosystems, and land reclamation (Mazlan et al., 2005).

Chinese marine fisheries production, including captive fisheries and aquaculture, has surpassed that of all other countries since the end of the twentieth century, and the serious overexploitation of living resources has decreased marine biodiversity (Liu, 2014).

Habitat loss, environmental degradation, pollution, and overexploitation of biological resources greatly influence the biodiversity and abundance of mollusks of the heavily populated basin of the South China Sea.

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Explanation of Plates

Plate 1

(Arcidae)

Figs. A, B. *Arca navicularis* Bruguière, 1789: South China Sea, Cambodia, Gulf of Thailand, Tampung Isl., 10°51' N, 103°09' E, ZMFU no. 8925/Bv-26, shell length 60.1 mm; **Figs. C, D.** *Anadara fultoni* (G.B. Sowerby III, 1907) (= *A. crebricostata* aucct. non Reeve, 1844): South China Sea, Thailand, Gulf of Thailand, Prachuap Khiri Khan Prov., ZMFU no. 27751/Bv-4694, shell length 70.1 mm; **Figs. E, F.** *Anadara antiquata* (L., 1758): South China Sea, China, Hainan Isl., Sintsun, depth 1 m, ZMFU no. 10634/Bv-912, shell length 53.4 mm; **Figs. G, H.** *Anadara globosa* (Reeve, 1844): South China Sea, Vietnam, Danang, ZMFU no. 28800/Bv-4919, shell length 63.9 mm; **Figs. I, J.** *Anadara kafanovi* Lutaenko, 1993: South China Sea, Vietnam, Danang, ZMFU no. 26580/Bv-4495, shell length 49.5 mm; **Figs. K, L.** *Anadara cornea* (Reeve, 1844): South China Sea, Vietnam, Fukhanh Prov., depth 2–10 m, ZMFU no. 11188/Bv-1272, shell length 42.8 mm; **Figs. M, N.** *Anadara guangdongensis* (Bernard, Cai et Morton, 1993): South China Sea, Vietnam, Tonkin Gulf, Bien-Shon Isl., ZMFU no. 14033/Bv-1757, shell length 33.9 mm.

Plate 2

(Arcidae)

Figs. A, B. *Anadara pilula* (Reeve, 1843): South China Sea, China, Hainan Isl., Sanya, ZMFU 10519/Bv-828, shell length 34.8 mm; **Figs. C, D.** *Anadara* cf. *gubernaculum* (Reeve, 1844): South China Sea, China, Hong Kong, Starfish Bay, ZMFU no. 10515/Bv-824, shell length 35.9 mm; **Figs. E, F.** *Anadara troscheli* (Dunker, 1882): South China Sea, Tonkin Gulf, ZMFU no. 10516/Bv-825, shell length 31.2 mm; **Figs. G, H.** *Anadara tricenicosta* (Nyst, 1848): South China Sea, Gulf of Thailand, Cambodia, ZMFU no. 8903/Bv-4, shell length 48.4 mm; **Figs. I, J.** *Anadara granosa* (L., 1758): South China Sea, Vietnam, Tonkin Gulf, Halong City, ZMFU no. 28828/Bv-4923, shell length 50.3 mm; **Figs. K, L.** *Anadara nodifera* (Martens, 1860): South China Sea, Vietnam, Tonkin Gulf, Halong Bay, Catba Isl., ZMFU no. 28833/Bv-4928, shell length 56.6 mm; **Figs. M, N.** *Anadara ferruginea* (Reeve, 1844): South China Sea, 00°12' N, 106°47' E, depth 49 m, ZMFU no. 11114/Bv-1214, shell length 20.9 mm.

Plate 3

(Arcidae (including Noetiinae), Cucullaeidae)

Figs. A, B. *Anadara subrubra* (Dunker, 1866): South China Sea, Vietnam, Khan Hoa Prov., Nha-trang City, ZMFU no. 43356/Bv-6592, shell length 42.7 mm; **Figs. C, D.** *Sheldonella lateralis* (Reeve, 1844): South China Sea, Gulf of Thailand, 09°05' N, 102°10' E, depth 70 m, ZMFU no. 10035/Bv-494, shell length 20.5 mm; **Figs. E, F.** *Nipponarca* cf. *adamsiana* (Dunker, 1866): South China Sea, Gulf of Thailand, 09°05' N, 102°10' E, depth 70 m, ZMFU no. 8930/Bv-31, shell length 35.5 mm; **Figs. G, H.** *Cucullaea labiata* (Lightfoot, 1786): South China Sea, Vietnam, Khan Hoa Prov., Nha-trang, ZMFU no. 20490/Bv-3249, shell length 124.5 mm; **Figs. I, J.** *Cucullaea* cf. *petita* Iredale, 1839: South China Sea, Cambodia, Gulf of Thailand, 10°21' N, 103°41' E, depth 16 m, ZMFU no. 8933/Bv-33, shell length 79 mm; **Figs. K, L.** *Barbatia decussata* (Sowerby I, 1833): South China Sea, Vietnam, ZMFU no. 27826/Bv-4775, shell length 67.2 mm; **Figs. M, N.** *Barbatia virescens* (Reeve, 1844): South China Sea, Vietnam, Cam Ranh Bay, ZMFU no. 13117/Bv-1730, shell length 41 mm; **Figs. O, P.** *Barbatia fusca* (Bruguière, 1789): South China Sea, Vietnam, Cam Ranh Bay, ZMFU no. 13116/Bv-1729, shell length 35.3 mm.

Plate 4

(Arcidae, Glycymerididae, Mytilidae)

Figs. A, B. *Barbatia virescens* (Reeve, 1844): South China Sea, Vietnam, Tonkin Gulf, Catba Isl., ZMFU no. 28843/Bv-4938, shell length 28.0 mm; **Figs. C.** *Barbatia trapezina* (Lamarck, 1819): South China Sea, China, Hong Kong, Hong Kong Isl., Shek O Beach, ZMFU no. 38501/Bv-5838, shell length 26.1 mm; **Figs. D, E.** *Trisidos tortuosa* (L., 1758): South China Sea, China, Hainan Isl., ZMFU no. 10625/Bv-903, shell length 70.5 mm; **Figs. F, G.** *Trisidos semitorta* (Lamarck, 1818): South China Sea, southern Vietnam, ZMFU no. 8923/Bv-24, shell length 69.0 mm; **Figs. H, I.** *Tucetona tsugioi* Matsukuma, 1984: South China Sea, Vietnam, Nha Trang Bay, Mun Isl., depth 8 m, ZMFU no. 28038/Bv-4837, shell length 48.2 mm; **Figs. J, K.** *Modiolus philippinarum* (Hanley, 1843): South China Sea, Vietnam, Phukhanh Prov., depth 2–10 m, ZMFU no. 9940/Bv-445, shell length 70.1 mm; **Figs. L, M.** *Modiolus modulaides* (Röding, 1798) (= *Modiola metcalfei* Hanley, 1843): South China Sea, Vietnam, Nhatrang City, ZMFU no. 18956/Bv-2590, shell length 48.6 mm; **Figs. N, O.** *Septifer virgatus* (Wiegmann, 1837): South China Sea, China, Hong Kong, Hong Kong Isl., Stanley Beach, ZMFU no. 37675/Bv-5456, shell length 56.5 mm.

Plate 5

(Mytilidae, Malleidae (Isognomoninae), Plicatulidae, Limidae)

Figs. A, B. *Amygdalum watsoni* (Smith, 1885): South China Sea, Vietnam, Tonkin Gulf, depth 67 m, ZMFU no. 10646/Bv-924, shell length 31.5 mm; **Figs. C, D.** *Perna viridis* (L., 1758): South China Sea, China, Hong Kong, Lantau Isl., Cheung Sha Beach, ZMFU no. 37677/Bv-5458, shell length 50.5 mm; **Figs. E, F.** *Isognomon isognomum* (L., 1758): South China Sea, Cambodia, Gulf of Thailand, depth 20 m, ZMFU no. 10481/Bv-808, shell height 75.4 mm; **Figs. G, H.** *Isognomon nucleus* (Lamarck, 1819): South China Sea, China, Hong Kong, Hong Kong Isl., Shek O Beach, ZMFU no. 38507/Bv-5844, shell height 18.5 mm; **Figs. I, J.** *Plicatula* sp.: South China Sea, Vietnam, Nhatrang, ZMFU no. 19557/Bv-2931, shell height 24.7 mm; **Fig. K, L.** *Acesta* cf. *rathbuni* (Bartsch, 1913): South China Sea, southern Vietnam, ZMFU no. 10746/Bv-1000, shell height 195.0 mm.

Plate 6

(Malleidae)

Figs. A, B. *Malleus albus* Lamarck, 1819: South China Sea, southern Vietnam, ZMFU no. 10898/Bv-1119, shell height 110.1 mm; **Figs. C, D.** *Malleus malleus* (L., 1758): South China Sea, southern Vietnam, depth 25 m, ZMFU no. 10900/Bv-1121, shell height 157.0 mm.

Plate 7

(Pteriidae, Pinnidae)

Figs. A, B. *Pteria penguin* (Röding, 1798): South China Sea, Cambodia, Gulf of Thailand, 10°3' N, 103°16' E, depth 23 m, ZMFU no. 10728/982, shell height 59.7 mm; **Figs. C, D.** *Pteria heteroptera* (Lamarck, 1819) (= *Avicula brevialata* Dunker, 1872): South China Sea, Cambodia, Gulf of Thailand, depth 20 m, ZMFU no. 10729/Bv-983, shell length 56.6 mm; **Figs. E, F.** *Pteria maura* (Reeve, 1857) (= *Avicula coturnix* Dunker, 1879): South China Sea, Cambodia, Gulf of Thailand, depth 20 m, ZMFU no. 10727/Bv-981, shell height 67.5 mm; **Figs. G, H.** *Pinctada margaritifera* (Linnaeus, 1758): South China Sea, Cambodia, Gulf of Thailand, Tang Isl., depth

4 m, ZMFU no. 10405/Bv-762, shell length 110.0 mm; **Figs. I, J.** *Pinctada imbricata fucata* (Gould, 1850): South China Sea, South China Sea, Cambodia, Gulf of Thailand, 10°21' N, 103°41' E, depth 16 m, ZMFU no. 10409/Bv-766, shell length 59.7 mm; **Figs. K, L.** *Atrina vexillum* (Born, 1778): South China Sea, Vietnam, Phu Khanh Prov., depth 2–10 m, ZMFU no. 10056/Bv-501, shell height 116.5 mm.

Plate 8
(Pinnidae)

Figs. A, B. *Atrina* sp.: South China Sea, Vietnam, Cam Ranh Bay, ZMFU no. 26252/Bv-4405, shell length 131.7 mm; **Figs. C, D.** *Pinna* sp.: South China Sea, Cambodia, Gulf of Thailand, 11°03' N, 103°00' E, depth 18 m, ZMFU no. 10051/Bv-496, shell length 106.2 mm; **Figs. E, F.** *Pinna* sp.: South China Sea, Cambodia, Gulf of Thailand, Tampong Isl., 10°51' N, 103°09' E, ZMFU no. 10040/Bv-1103, shell height 129.6 mm; **Figs. G, H.** *Pinna atropurpurea* G.B. Sowerby I, 1825: South China Sea, Cambodia, Gulf of Thailand, depth 20 m, ZMFU no. 10737/Bv-991, shell height 65.6 mm.

Plate 9
(Pinnidae, Placunidae, Spondylidae)

Figs. A, B. *Pinna trigonium* Dunker, 1852 (= *P. fumata* Reeve, 1858): South China Sea, southern Vietnam, Gulf of Thailand, Namzu Islands, ZMFU no. Bv-10039/495, shell height 296 mm; **Figs. C, D.** *Atrina pectinata* (L., 1767): South China Sea, Cambodia, Gulf of Thailand, Tampong Isl., 10°51' N, 103°09' E, ZMFU no. 10055/Bv-500, shell height 130.3 mm; **Figs. E.** *Placuna placenta* (L., 1758): South China Sea, Cambodia, Gulf of Thailand, depth 20 m, ZMFU no. 10152/Bv-587, shell length 87.4 mm; **Figs. F, G.** *Placuna ephippium* (Philipsson, 1788) (= *P. sella* (Gmelin, 1791)): South China Sea, southern Vietnam, ZMFU no. 10102/Bv-542, shell length 144.1 mm; **Figs. H, I.** *Spondylus* cf. *regius* L., 1758: South China Sea, Cambodia, Gulf of Thailand, depth 20 m, ZMFU no. 10752/Bv-1006, shell height 50.4 mm.

Plate 10
(Ostreidae, Gryphaeidae)

Figs. A, B. *Hyotissa* sp.: South China Sea, Cambodia, Gulf of Thailand, ZMFU no. 10227/Bv-625, shell height 75.1 mm; **Figs. C, D.** *Dendostrea* cf. *cristata* (Born, 1778): South China Sea, southern Vietnam, ZMFU no. 9554/Bv-351, shell height 66.7 mm; **Figs. E, F.** *Dendostrea* cf. *rosacea* (Deshayes, 1836): South China Sea, Cambodia, Gulf of Thailand, depth 20 m, ZMFU no. 10242/Bv-631, shell height 54.7 mm; **Figs. G, H.** *Dendostrea folium* (L., 1758): South China Sea, Cambodia, Gulf of Thailand, 11°02' N, 103°00' E, depth 13 m, ZMFU no. 10241/Bv-630, shell height 46.3 mm; **Figs. I, J.** *Hyotissa hyotis* (L., 1758): South China Sea, Cambodia, Gulf of Thailand, Tang Isl., depth 2 m, ZMFU no. 9559/Bv-356, shell height 150.0 mm; **Figs. K, L.** *Hyotissa* cf. *hyotis* (L., 1758): South China Sea (?), ZMFU no. 12571/Bv-1618, shell height 142.3 mm.

Plate 11
(Pectinidae, Carditidae)

Figs. A, B. *Amusium pleuronectes* (L., 1758): South China Sea, Cambodia, Gulf of Thailand, ZMFU no. 17523/Bv-2414, shell length 70.5 mm; **Figs. C, D.** *Minnivola pyxidata* (Born, 1778): South China Sea, Cambodia, Gulf of Thailand, Tampong Isl., 10°51' N, 103°09' E, ZMFU

no. 11287/Bv-1343, shell length 28.5 mm; **Figs. E.** *Annachlamys striatula* (L., 1758): South China Sea, Vietnam, Nhatrang, ZMFU no. 34305/Bv-5278, shell length 66.0 mm; **Figs. F.** *Mimachlamys crassicostata* (G.B. Sowerby II, 1842): South China Sea, China, Hong Kong, Hong Kong Isl., Stanley Beach, ZMFU no. 38217/Bv-5718, shell length 38.1 mm; **Figs. G, H.** *Decatopecten radula* (L., 1758): South China Sea, Vietnam, ZMFU no. 25385/Bv-4256, shell length 84.3 mm; **Figs. I, J.** *Cardita leana* Dunker, 1860: South China Sea, China, Hong Kong, Hong Kong Isl., Cape D'Aguilar, ZMFU no. 25215/Bv-4323, shell length 23.3 mm; **Figs. K, L.** *Cardita variegata* Bruguière, 1792: South China Sea, Vietnam, ZMFU no. 25328/Bv-4240, shell length 34.9 mm.

Plate 12

(Chamidae, Trapezidae, Glossidae, Cardiidae)

Figs. A, B. *Chama pacifica* Broderip, 1835: South China Sea, Cambodia, Gulf of Thailand, depth 20 m, ZMFU no. 10293/Bv-676, shell length 17.5 mm; **Figs. C, D.** *Chama macerophylla* Gmelin, 1791 (= *Ch. lazarus* L., 1758): South China Sea, Vietnam, ZMFU no. 11969/Bv-1509, shell length 32.6 mm; **Figs. E, F.** *Coralliophaga coralliophaga* (Gmelin, 1791): South China Sea, China, Hainan Isl., Sanya, ZMFU no. 10331/Bv-708, shell length 27.9 mm; **Figs. G, H.** *Meiocardia vulgaris* (Reeve, 1845): South China Sea, Cambodia, Gulf of Thailand, 09°56' N, 103°08' E, depth 30 m, ZMFU no. 9913/Bv-432, shell length 28.5 mm; **Figs. I, J.** *Fragum unedo* (L., 1754): South China Sea, Vietnam, Fukhanh Prov., depth 2–10 m, ZMFU no. 10094/Bv-535, shell length 41.7 mm; **Figs. K, L.** *Fulvia* sp.: South China Sea, Vietnam, Nhatrang, ZMFU no. 18943/Bv-2584, shell length 32.0 mm.

Plate 13

(Cardiidae)

Figs. A, B. *Lunulicardia retusa* (L., 1767): South China Sea, Vietnam, Nhatrang, ZMFU no. 18957/Bv-2591, shell length 17.9 mm; **Figs. C, D.** *Vasticardium pectiniforme* (Born, 1780): South China Sea, Vietnam, Nhatrang, ZMFU no. 18953/Bv-2587, shell length 32.2 mm; **Figs. E, F.** *Vasticardium subrugosum* (G.B. Sowerby II, 1839): South China Sea, Vietnam, Fukhanh Prov., depth 2–10 m, ZMFU no. 9137/Bv-133, shell length 43.8 mm; **Figs. G, H.** *Acrosterigma impolitum* (G.B. Sowerby II, 1841): South China Sea, Gulf of Thailand, Cambodia, 09°56' N, 103°08' E, depth 30 m, ZMFU no. 11197/Bv-1281, shell length 22.9 mm; **Fig. I, J.** *Acrosterigma attenuatum* (G.B. Sowerby II, 1841): South China Sea, Vietnam, Nhatrang, ZMFU no. 18966/Bv-2600, shell length 36.8 mm.

Plate 14

(Cardiidae, Mactridae)

Figs. A, B. *Vepricardium sinense* (G.B. Sowerby II, 1839): South China Sea, Vietnam, Nhatrang, ZMFU no. 18942/Bv-2583, shell length 24.8 mm; **Figs. C, D.** *Vepricardium coronatum* (Schröter, 1786): South China Sea, Vietnam, Nhatrang, ZMFU no. 18967/Bv-2601, shell length 37.3 mm; **Figs. E, F.** *Vepricardium multispinosum* (G.B. Sowerby II, 1839): South China Sea, Gulf of Thailand, Cambodia, 09°57' N, 103°08' E, depth 30 m, ZMFU no. 11282/Bv-1340, shell length 29.2 mm; **Figs. G, H.** *Lutraria arcuata* Deshayes, 1854: South China Sea, China, Hong Kong, ZMFU no. 25207/Bv-4225, shell length 79.6 mm.

Plate 15

(Mactridae, Mesodesmatidae)

Figs. A, B. *Mactra antiquata* Spengler, 1802: South China Sea, China, Hong Kong, ZMFU no. 25206/Bv-4224, shell length 82.5 mm; **Figs. C, D.** *Mactra achatina* Holten, 1802 (= *M. ornata* Gray, 1837): South China Sea, Thailand, Gulf of Thailand, Hua Hin, ZMFU no. 27937/Bv-4795, shell length 30.3 mm; **Figs. E, F.** *Mactra grandis* Gmelin, 1791: South China Sea, Vietnam, Fukhanh Prov., depth 2–10 m, ZMFU no. 9106/Bv-102, shell length 72.0 mm; **Figs. G, H.** *Mactra maculata* Gmelin, 1791: South China Sea, Vietnam, Nhatrang, ZMFU no. 19069/Bv-2649, shell length 46.1 mm; **Fig. I.** *Standella pellucida* (Gmelin, 1791): South China Sea, Vietnam, Nhatrang, ZMFU no. 19076/Bv-2656, shell length 37.6 mm; **Fig. J.** *Meropesta nicobarica* (Gmelin, 1791): South China Sea, China, Hong Kong, Hong Kong Isl., Stanley Beach, ZMFU no. 37674/Bv-5455, shell length 45.3 mm; **Figs. K, L.** *Atactodea striata* (Gmelin, 1791): South China Sea, South China Sea, China, Hong Kong, Hong Kong Isl., Cape d'Aguilar, ZMFU no. 25219/Bv-4237, shell length 28.0 mm.

Plate 16

(Tellinidae, Solecurtidae)

Figs. A, B. *Pharaonella aurea* (G. Perry 1811) (= "*Pharaonella rostrata*" aucct. non L., 1758): South China Sea, Thailand, Gulf of Thailand, ZMFU no. 27969/Bv-4826, shell length 63.5 mm; **Fig. C.** *Scutarcopagia pulcherrima* (G.B. Sowerby I, 1825): South China Sea, Vietnam, Nhatrang, ZMFU no. 19078/Bv-2658, shell length 43.8 mm; **Figs. D, E.** *Dallitellina rostrata* (Linnaeus 1758) (= *Tellina spengleri* Gmelin, 1791): South China Sea, Vietnam, Cam Ranch Bay, ZMFU no. 13119/Bv-1732, two different valves with same length, shell length 66.2 mm; **Figs. F, G.** *Solecurtus philippinarum* (Dunker, 1862): South China Sea, Vietnam, Cam Ranh Bay, ZMFU no. 13118/Bv-1731, shell length 43.9 mm.

Plate 17

(Psammobiidae, Veneridae)

Figs. A, B. *Asaphis violascens* (Forsskal in Niebuhr, 1775): South China Sea, Cambodia, Gulf of Thailand, Kompong Som Bay, ZMFU no. 19132/Bv-2700, shell length 22.8 mm; **Figs. C, D.** *Asaphis violascens* (Forsskal in Niebuhr, 1775): South China Sea, Malaysia, Borneo Isl., Kota Kinabalu, ZMFU no. 27209/Bv-4531, shell length 48.2 mm; **Figs. E, F.** *Hiatula chinensis* (Mörch, 1853): South China Sea, Vietnam, Cam Ranh Bay, ZMFU no. 26254/Bv-4407, shell length 79.2 mm; **Figs. G, H.** *Gari maculosa* (Lamarck, 1818): South China Sea, China, Hong Kong, Hong Kong Isl., Cape D'Aguilar, ZMFU no. 25214/Bv-4232, shell length 45.0 mm; **Figs. I, J.** *Ruditapes philippinarum* (Adams et Reeve, 1850): South China Sea, China, Hong Kong, ZMFU no. 25209/Bv-4227, shell length 39.3 mm; **Figs. K, L.** *Antigona lamellaris* (Schumacher, 1817): South China Sea, Cambodia, Gulf of Thailand, 09°56' N, 103°08' E, depth 30 m, ZMFU no. 9530/Bv-327, shell length 32.1 mm; **Figs. M, N.** *Lioconcha castrensis* (Linnaeus, 1758): South China Sea, Vietnam, Nha Trang Bay, Mun Isl., 12°09.79' N, 109°18.02' E, depth 8 m, ZMFU no. 28035/Bv-4834, shell length 27.2 mm.

Plate 18

(Veneridae)

Figs. A, B. *Marcia hiantina* (Lamarck, 1818): South China Sea, Vietnam, Nhatrang, ZMFU no. 18969/Bv-2603, shell length 46.7 mm; **Figs. C, D.** *M. hiantina* (Lamarck,

1818): South China Sea, Vietnam, Nhatrang, ZMFU no. 17529/Bv-2420, shell length 47.7 mm; **Figs. E, F.** *Anomalodiscus squamosus* (L., 1758): South China Sea, Vietnam, Nhatrang, ZMFU no. 18963/Bv-2597, two different valves with same length, shell length 26.6 mm; **Figs. G, H.** *Timoclea marica* (L., 1758): South China Sea, Vietnam, Phukhanh Prov., depth 2–10 m, ZMFU no. 9539/Bv-336, shell length 19.0 mm; **Figs. I, J.** *Gomphina donacina* (Megerle von Mühfeld, 1811) (= *G. semicancellata* Koch in Philippi, 1843): South China Sea, Vietnam, Nhatrang, ZMFU no. 19418/Bv-2889, shell length 47.1 mm; **Figs. K, L.** *Paphia undulata* (Born, 1778): South China Sea, Vietnam, Nhatrang, ZMFU no. 19072/Bv-2652, shell length 55.5 mm; **Figs. M, N.** *Paphia kreipli* Huber, 2010: South China Sea, China, Hong Kong, ZMFU no. 25201/Bv-4219, shell length 62.9 mm.

Plate 19

(Veneridae)

Figs. A, B. *Tapes dorsatus* (Lamarck, 1818): South China Sea, China, Hong Kong, ZMFU no. 25208/Bv-4226, shell length 70.1 mm; **Figs. C, D.** *Marcia japonica* (Gmelin, 1791): South China Sea, Vietnam, Phukhanh Prov., ZMFU no. 11242/Bv-1319, shell length 42.9 mm; **Figs. E, F.** *Meretrix lamarckii* Deshayes, 1853: South China Sea, Vietnam, Cam Ranh Bay, ZMFU no. 22909/Bv-3685, shell length 53.1 mm; **Figs. G, H.** *Meretrix* cf. *lusoria* (Röding, 1798): South China Sea, Vietnam, Cam Ranh Bay, ZMFU no. 13121/Bv-1734, shell length 52.9 mm; **Figs. I, J.** *Meretrix meretrix* (L., 1758): South China Sea, Malaysia, Borneo Isl., Kota Kinabalu, ZMFU no. 27208/Bv-4530, shell length 49.3 mm; **Figs. K, L.** *Callista grata* (Deshayes, 1853): South China Sea, Vietnam, Nhatrang, ZMFU no. 18964/Bv-2598, shell length 62.9 mm.

Plate 20

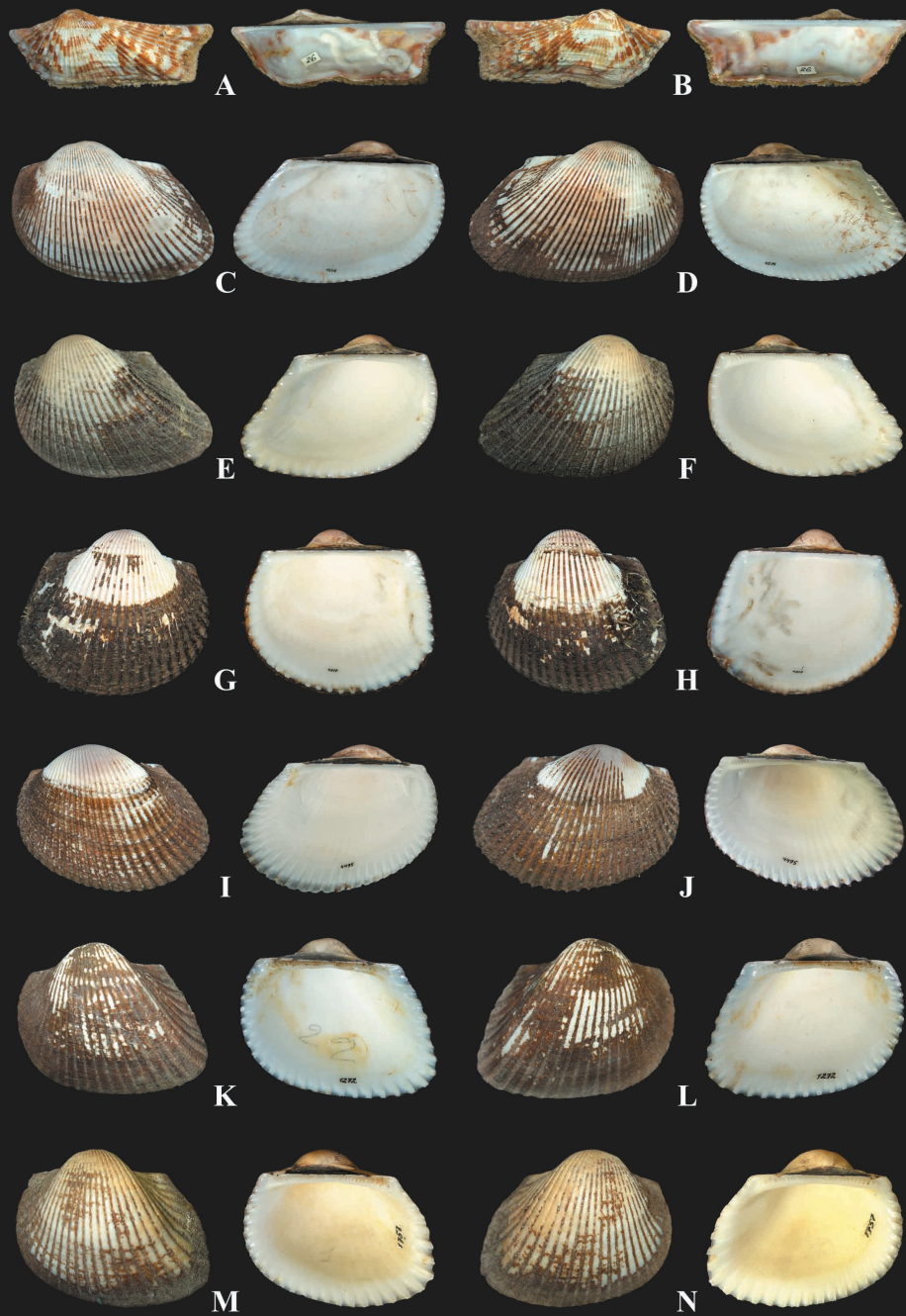
(Veneridae, Corbulidae, Pholadidae)

Figs. A, B. *Meretrix lyrata* (G.B. Sowerby II, 1851): South China Sea, Vietnam, Ho Chi Minh (Saigon), ZMFU no. 22664/Bv-3613, shell length 41.7 mm; **Figs. C, D.** *Gafrarium pectinatum* (L., 1758) (forma *tumidum*): South China Sea, Cambodia, Gulf of Thailand, Kompong Som Bay, Ko Pource Isl., ZMFU no. 19198/Bv-2743, shell length 22.3 mm; **Figs. E, F.** *Gafrarium divaricatum* (Gmelin, 1791): South China Sea, China, Hong Kong, Hong Kong Isl., Cape D'Aguilar, ZMFU no. 25210/Bv-4228, shell length 35.9 mm; **Figs. G, H.** *Corbula erythrodon* Lamarck, 1818: South China Sea, Cambodia, Gulf of Thailand, 10°44' N, 103°08' E, depth 20 m, ZMFU no. 11432/Bv-1418, shell length 20.8 mm; **Figs. I, J.** *Corbula hydropica* (Iredale, 1930): South China Sea, Vietnam, Nhatrang, ZMFU no. 19074/Bv-2654, shell length 24.5 mm; **Figs. K, L.** *Martesia* cf. *striata* (L., 1758): South China Sea, Vietnam, Nhatrang, ZMFU no. 18958/Bv-2592, shell length 24.8 mm.

Plate 21

(Pholadidae)

Figs. A, B. *Pholadidea fauroti* Jousseaume, 1888: South China Sea, Vietnam, ZMFU no. 25167/Bv-4196, shell length 18.4 mm; **Figs. C, D.** *Martesia* sp.: South China Sea, Vietnam, Tonkin Gulf, Daochao Isl., ZMFU no. 25164/Bv-4193, shell length 23.4 mm; **Figs. E, F.** *Barnea* cf. *australasiae* (G. B. Sowerby II, 1849): South China Sea, Vietnam, ZMFU no. 9361/Bv-257, shell length 45.2 mm.





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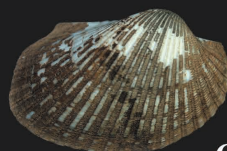
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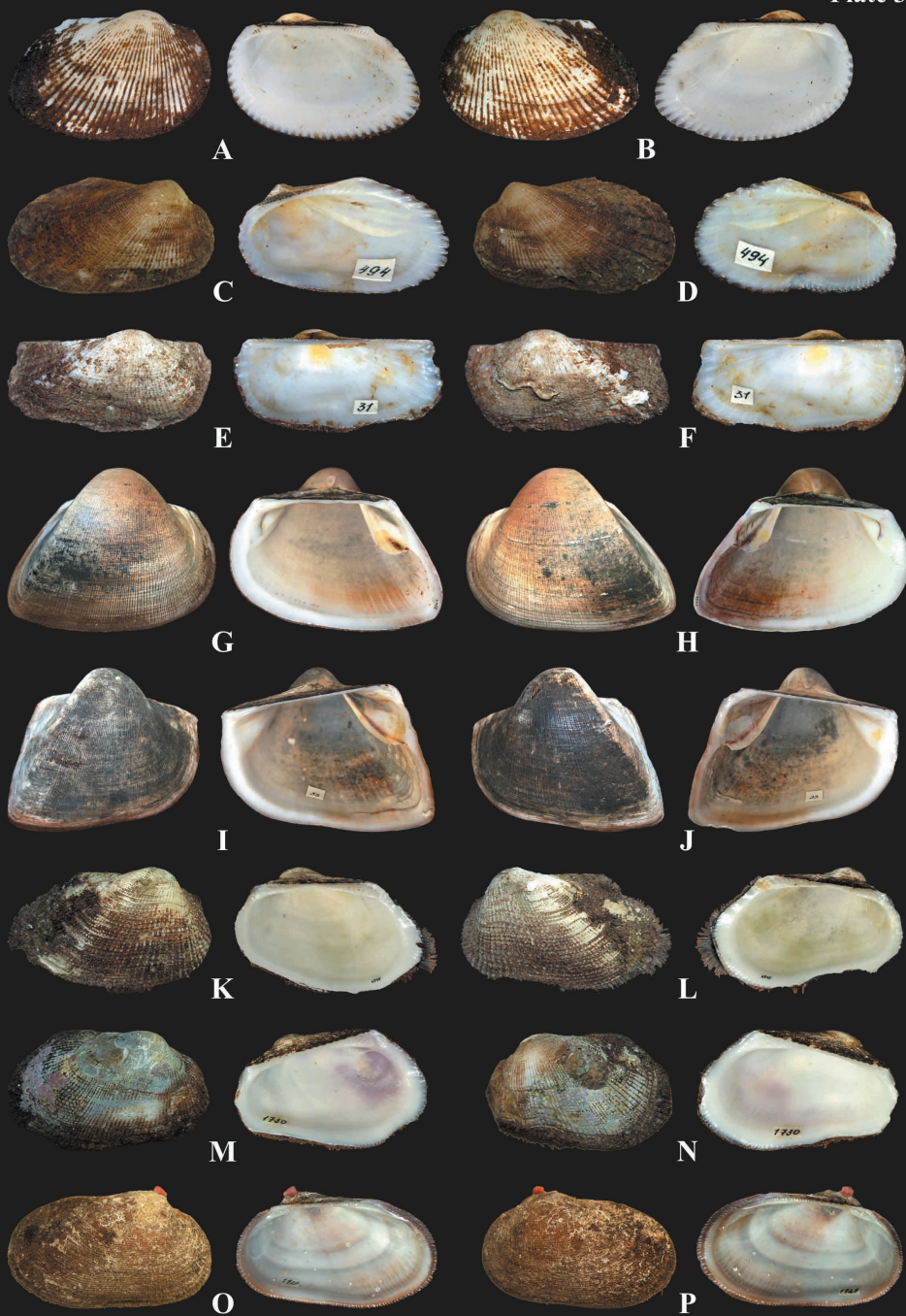


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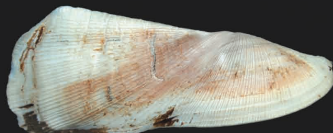
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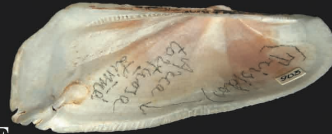
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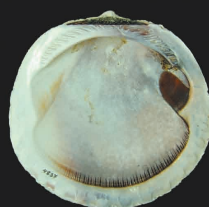
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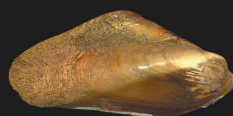
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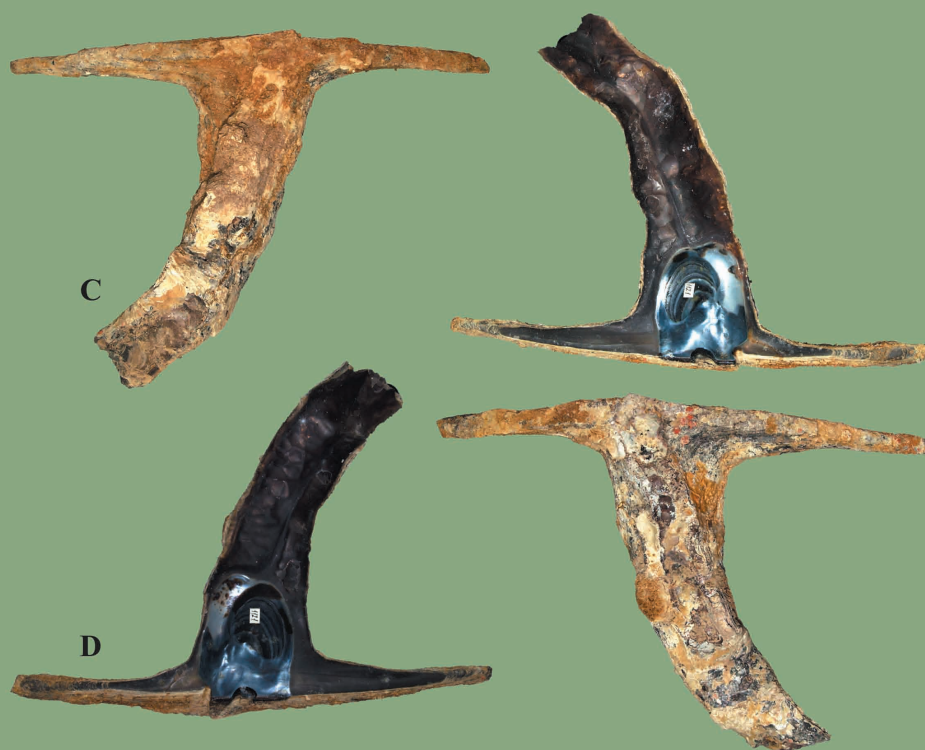
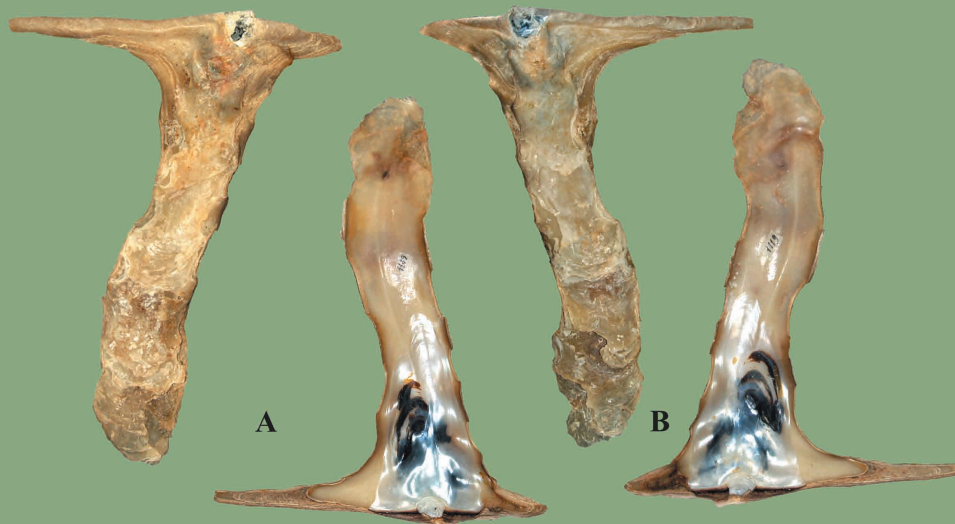


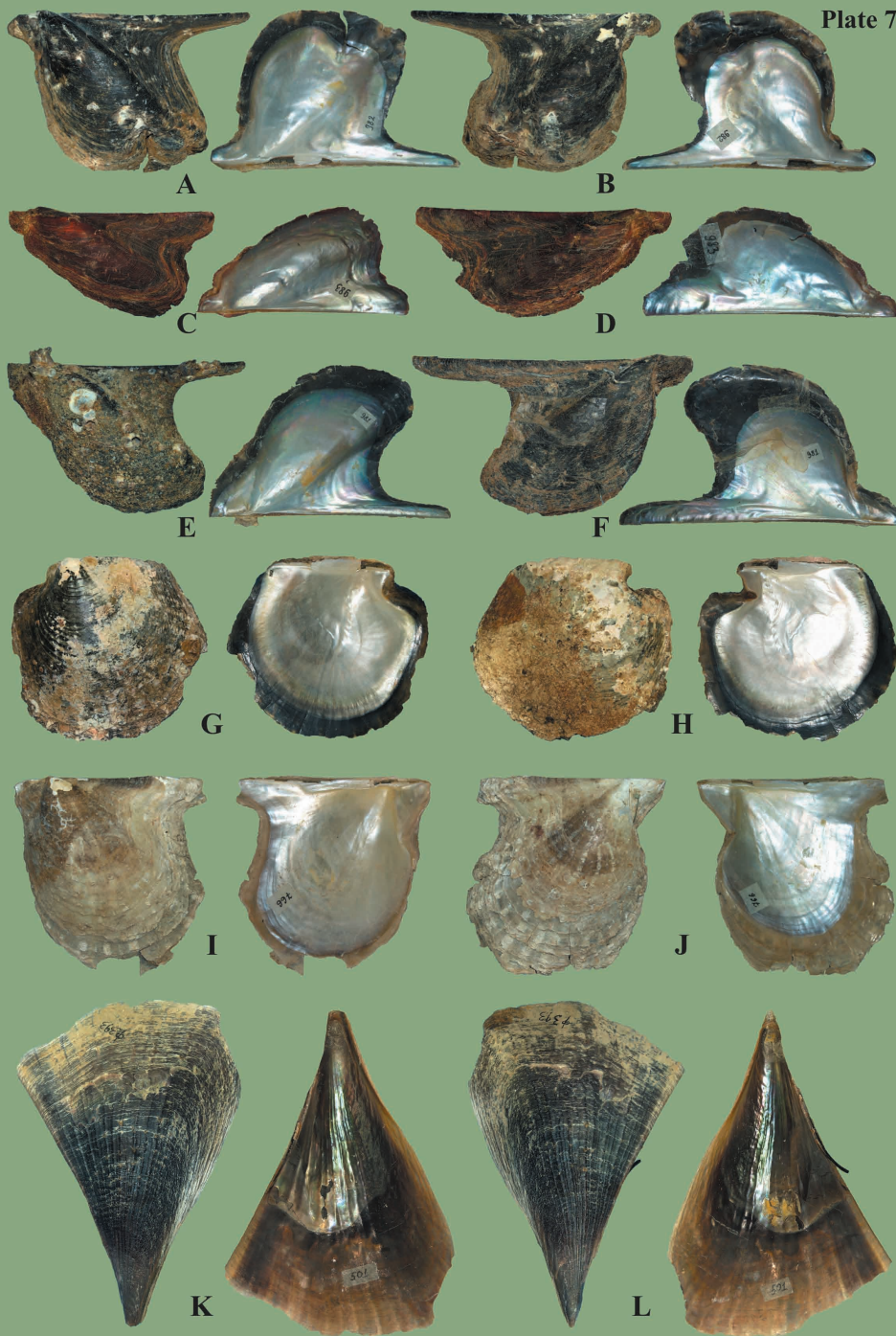
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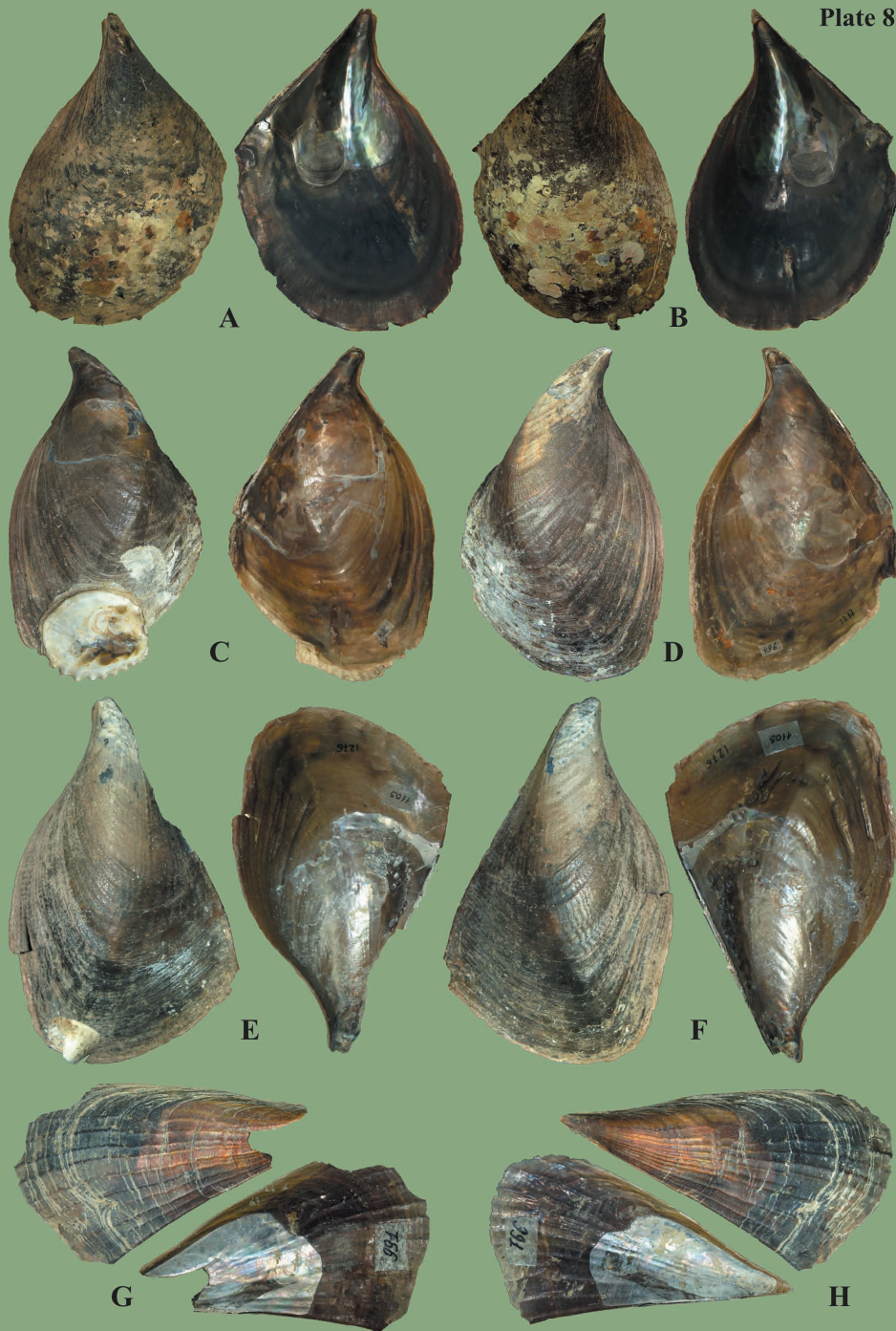


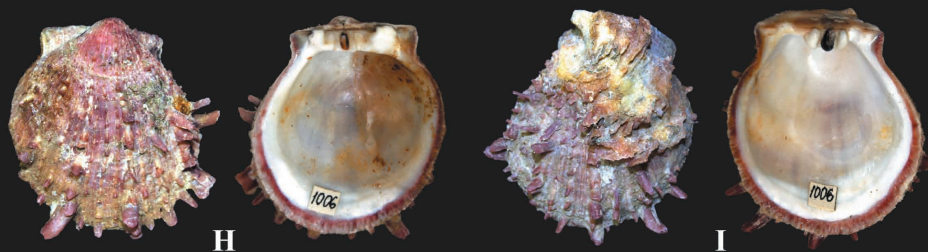
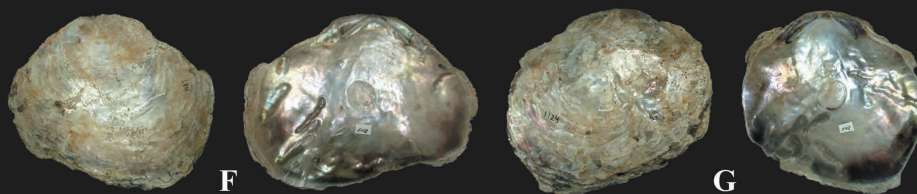
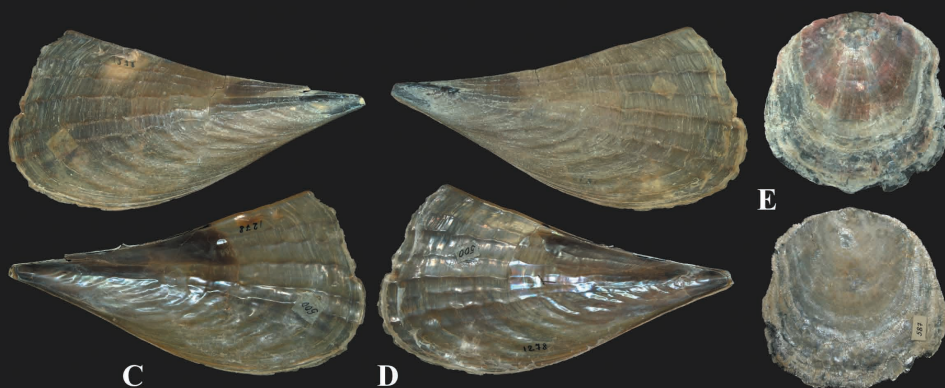
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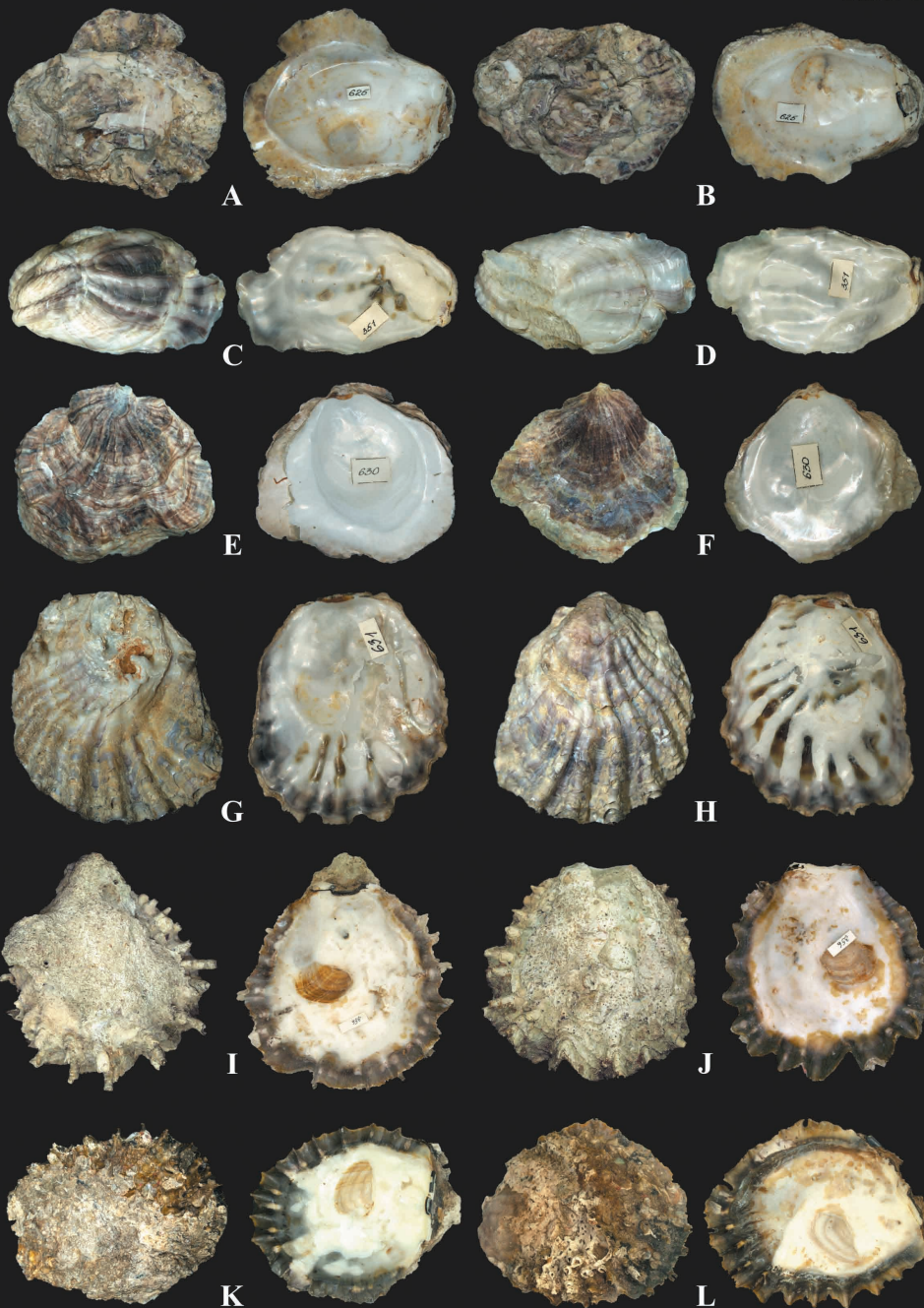




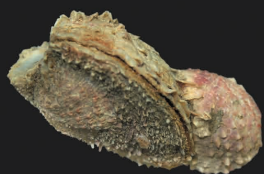








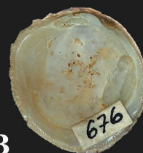




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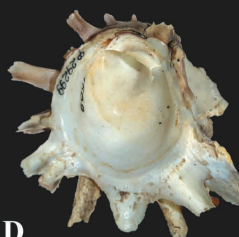
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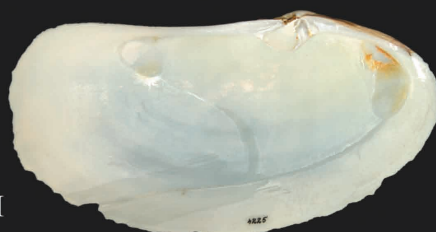
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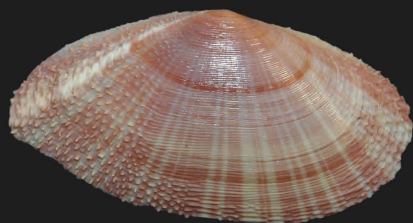




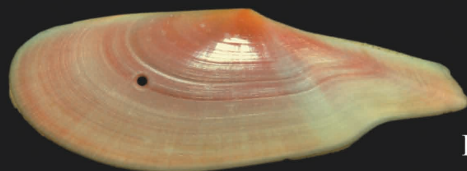
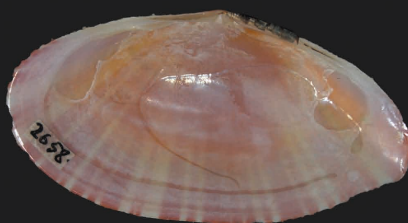
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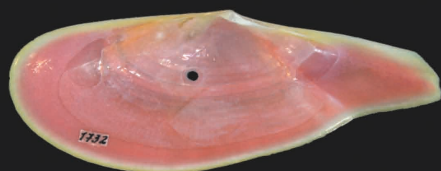
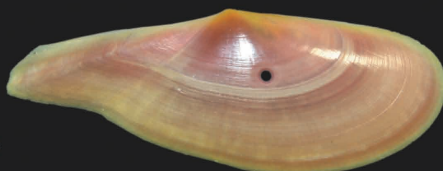
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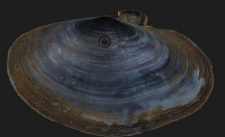
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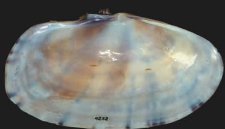
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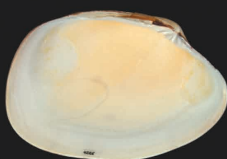
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Algal communities in the intertidal and upper subtidal zones of the coral reef of Luhuitou Peninsula (Sanya Bay, Hainan Island) in the spring season

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Abstract: According to the floristic study conducted in the intertidal and upper subtidal zones of the Luhuitou reef, marine macroalgae occupied mostly hard substrates (rocky bottom, carbonate reef basis, dead coral colonies and their debris). Intertidal algal communities were mainly represented by algal turf and crust algae. In the subtidal zone, fleshy, frondose and foliose algae enriched algal turf communities. *Sargassum* spp. community occupied the upper border of the subtidal zone.

Key words: inventory, macroalgae, algal communities, South China Sea, Hainan, pollution, new records.

Hainan Island (Fig. 1) is located in the subtropical northern periphery of the Indo-Pacific in the South China Sea (18°10'–20°9' N, 108°37'–111°1' E). The island has an area of 33920 km² and a coastline of more than 1000 miles. The annual mean sea surface temperature (SST) is 26°C (1970–2002) with an average seasonal range within 12.1°C (Sun et al., 2005). The annual SST maximum (30.8°C) and minimum (18.7°C) commonly occurs in July and January, respectively. Mean sea surface salinity (SSS) in the South China Sea fluctuates between 33.3 and 34.0‰. However, SSS is strongly seasonal at Hainan Island, decreasing to a mean value of 26.5‰ due to freshwater runoff and rain during the summer wet season (Levitus, Boyer, 1994). The mean tidal range is mostly less than 1.5 m (Zhang et al., 1996).

The coral reefs of Hainan Island are one of the most prominent fringing reefs of China. The coral reef species diversity has a general declining trend. The highest



Fig. 1. Schematic map of the area of study, Luhuitou reef.

biodiversity was recorded between the 1950s and 1960s (Gurianova, 1959) but decreased severely in the following 20 years (Hutchings, Wu, 1987; Zhang et al., 2006). Almost 80% of the fringing reefs along the coastline of Hainan Island (including the coral reef of Luhuitou Peninsula) are damaged due to human activities, including dynamite fishing, which posed a major threat to this valuable habitat (Hutchings, Wu, 1987; Fiege et al., 1994; Hodgson, Yau, 1997; Tadashi et al., 2008). Increasing tourism with hotels built directly on the beach (especially in Sanya Bay) and aquaculture (all along the coast of Hainan Island) have also endangered the coastal marine fauna and flora since the 1990s (Zhang et al., 2004).

In previous studies we showed that in the seawater of Luhuitou and Xiaodonghai reefs in Sanya Bay nutrient levels varied mainly in respect to seasons; dissolved inorganic nitrogen (DIN) ranged from 0.84 to 3.93 μM , ammonium 0.65–2.73 μM , nitrate 0.08–1.93 μM , and nitrite 0.04–0.39 μM . The highest DIN was observed in January and April. The content of phosphates varied between 0.04 and 0.39 μM , with the highest values observed in January. These findings suggest

that most of the year the seawater was sufficiently enriched with dissolved nitrogen and phosphorus accessible for plants at the sites investigated in Sanya Bay (Titlyanov et al., 2011).

It is known that inputs of DIN (such as ammonium, nitrate, and nitrite) through sewage, fertilizer runoff or wastes of marine animal farms frequently increase the rate of primary production in coastal ecosystems (Doering et al., 1995; Taylor et al., 1999; Thornber et al., 2008), which can lead to large-scale blooms of phytoplankton and/or macroalgae (Harlin, 1995; Doering et al., 1995; Nixon, Buckley, 2002). Macroalgal blooms can create large piles of decaying biomass on beaches when drift macroalgae are washed ashore (Rosenberg, 1985; Raffaelli et al., 1998). The thalli of bloom-forming species are typically characterized by high surface area: volume ratios (either thin and blade-like or filamentous and repeatedly branched), enabling fast uptake of nutrients (Littler et al., 2006). Blooms most commonly consist of green algae (Abou-Aisha et al., 1997). High concentrations of DIN and soluble reactive phosphorus (SRP) promote high biomass accumulation of not only filamentous green algae, but also frondose algae such as *Sargassum polyceratum* Montagne, *Lobophora variegata* (J.V. Lamouroux) Womersley ex E.C. Oliveira and *Halimeda opuntia* (Linnaeus) J.V. Lamouroux (Lapointe, 1997). In coral reefs, especially damaged earlier by bleaching or by other natural catastrophes, enrichment of waters with anthropogenic nitrogen promotes the growth of seaweeds and over-accumulation of their biomass in shallow areas. These processes decrease the competition ability of corals and prevent the recovery of the reef (Titlyanov, Titlyanova, 2008).

Eutrophication of waters may change the composition of macroalgal associations. It is shown that ephemeral fast-growing green algae in the intertidal and upper-subtidal zones displace slow-growing macroalgae. Frondose and fleshy algae become quickly overgrown by epiphytes, which can even prevail in biomass (Morand, Briand, 1996; Morand, Merceron, 2004; Lapointe et al., 2005a, b).

We investigated composition and distribution of mass macroalgal species growing on the coral reef of Luhuitou Peninsula in Sanya Bay (Hainan Island, China). We hypothetically proposed that seawater in Sanya Bay (significantly polluted with DIN) should negatively influence damaged coral reefs of Luhuitou Peninsula and their restoration, resulting in the changes of algal communities' structure and the increase in the competitive abilities of algae in comparison with corals. The aim of the present study was to estimate the influence of eutrophication on the structure of algal communities in the intertidal and upper subtidal zones of Luhuitou coral reef.

Materials and methods

Study site, time and conditions

Investigations were conducted at the Luhuitou reef, Sanya Bay, Hainan Island, China. The algae were collected in front of the Marine Biological Station of the South China Sea Institute of Oceanology CAS in the intertidal and upper subtidal zones (up to 5 m depth) in April 2009 (Fig. 1). In the spring period, surface water temperature near the station was 24–28°C. Incident surface photosynthetically active radiation (PAR_0) was 800–1600 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$ at around noon of a sunny day.

Collecting, preserving and identifying marine plants

In April 2009, seaweeds were collected in the upper, middle, and lower intertidal and in the upper subtidal zones (see Table). The collected specimens were preserved as a dried herbarium. Freshly collected material was identified using monographic publications, floristic studies and systematic articles (Börjesen, 1913a, b, c, 1940, 1948; Yamada, 1934, 1938; Tseng, 1936, 1938, 1942, 1983; Shen, Fan, 1950; Egerod, 1952; Dawson, 1954, 1956, 1957, 1961, 1962; Taylor, 1960; Durairatnam, 1961; Chiang, 1962; Womersley, 1967, 1984, 1987, 1994; Trono, 1968, 1969, 1997; Pham Hoang Ho, 1969; Womersley, Bailey, 1970; Itono 1972; Reyes, 1976; Tseng, Dong, 1978; Vinogradova, 1979; Lu, Tseng, 1980; Tseng et al., 1980; Trono, Put, 1982; Tseng, Lu, 1983; Dong, Tseng, 1985; Trono, Ganzon-Fortes, 1988; Kornmann, 1989; Price, Scott, 1992; Wynne, 1993, 1995; Draisma et al., 1998; Littler, Littler, 2000, 2003; Tseng et al., 2001, 2005; Abbott, Huisman, 2003; Leliaert, Coppejans, 2003; South, Skelton, 2003; Xia et al., 2004; Skelton, South, 2007; Dawes, Mathieson, 2008; Liu, 2008; Zheng, Li, 2009). The systematics and nomenclature followed M.D. Guiry and G.M. Guiry (<http://www.algaebase.org>; searched on 25 November 2015).

Analysis of algal communities

The abundance of algal communities on the bottom was determined visually and by photographs using the percentage (%) of projective surface of the bottom occupied by a certain algal community. The communities with the projective surface area less than 10% were marked as “rare” (+). The communities with the projective surface area between 10% and 30% were marked as “common” (++). The communities with the projective surface area between 30 to 50% or more were marked as “abundant” (+++). Algal dominance in the communities was determined visually.

Species composition, abundance and distribution of marine plants in Sanya Bay at Luhuitou coral reef in April 2009

ID	WA	UI	MI	LI	US	Comments
RHODOPHYTA						
Order STYLONEMATATALES						
Family Stylonemataceae						
<i>Chroodactylon ornatum</i> (C. Agardh) Basson	+ E ₁	+ E _{2,3,4,5}			+ E ₆	E ₁ – epiphyte on <i>Lomentaria corallicola</i> ; E ₂ – epiphyte on <i>P. japonica</i> var. <i>savatierei</i> ; E ₃ – epiphyte on <i>C. cimbrium</i> ; E ₄ – epiphyte on <i>Parvocaulis clavatus</i> stalk; E ₅ – epiphyte on <i>Ceratodicyon intricatum</i> ; E ₆ – epiphyte on <i>S. polycystum</i>
<i>Stylonema alsidii</i> (Zanardini) K.M. Drew			+ E _{1,2}	+ E ₃	+ E ₄	E ₁ – epiphyte on <i>Ceramium cimbrium</i> ; E ₂ – epiphyte on <i>Lomentaria corallicola</i> ; E ₃ – epiphyte on <i>Polysiphonia japonica</i> var. <i>savatierei</i> ; E ₄ – epiphyte on <i>Sargassum polycystum</i>
Order ERYTHROPELTIDALES						
Family Erythrotrichiaceae						
<i>Erythrotrichia carnea</i> (Dillwyn) J. Agardh	+ E ₁	+ E _{2,3}	+ E _{4,5,6,7,8}	+ E ₉	+ E ₁₀	E ₁ – epiphyte on <i>Hypnea spinella</i> ; E ₂ – epiphyte on <i>L. corallicola</i> ; E ₃ – epiphyte on <i>Cladophora laetevirens</i> ; E ₄ – epiphyte on <i>P. clavatus</i> stalk; E ₅ – epiphyte on <i>C. cimbrium</i> ; E ₆ – epiphyte on <i>Parviphycus pannosus</i> ; E ₇ – epiphyte on <i>C. intricatum</i> ; E ₈ – epiphyte on <i>Parvocaulis clavatus</i> stalk; E ₉ – epiphyte on <i>Gelidium pusillum</i> ; E ₁₀ – epiphyte on <i>Padina boryana</i>
<i>Erythrocladia irregularis</i> Rosenvinge					+ E	E – epiphyte on <i>Anadyomene wrightii</i> , <i>Caulerpa serrulata</i> , <i>Cladophora catenata</i> , <i>Phyllocladon anastomosans</i> stalks, <i>Siphonocladus rigidus</i> , <i>Valoniopsis pachynema</i>
<i>Sablingia subintegra</i> (Rosenvinge) Kormmann					+ E ₁	E ₁ – epiphyte on <i>Valonia ventricosa</i>

Table (Continued)

ID	WA	UI	MI	LJ	US	Comments
Order ACROCHAETIALES						
Family Acrochaetiaceae						
<i>Acrochaetium microscopium</i> (Nägeli ex Kützing) Nägeli					+ E _{1,2}	E ₁ – epiphyte on <i>S. polycystum</i> ; E ₂ – epiphyte on <i>Ceramium sympodiale</i>
<i>Acrochaetium robustum</i> Børgesen					+ E	E – epiphyte on <i>Bryopsis pennata</i> , <i>Phyllocladon anastomosans</i> stalk, <i>Padina australis</i> , <i>Sargassum</i> spp., <i>Ceramium borneense</i> , <i>Corallophila klerwegii</i> , <i>Neosiphonia sphaerocarpa</i> , <i>Pterocladia caerulea</i>
Order COLACONEMATATALES						
Family Colaconematataceae						
<i>Colaconema gracile</i> (Børgesen) Atweberhan et Prud'homme van Reine			+ Eb			Eb – epibiont on hydroids; E ₁ – epiphyte on <i>S. polycystum</i>
<i>Colaconema hypnaceae</i> (Børgesen) A.A. Santos et C.W.N. Moura			+ E ₁ , O	+ E ₂		E ₁ – epiphyte on <i>C. intricatum</i> ; E ₂ – epiphyte on <i>P. japonica</i> var. <i>sarvatierei</i>
Order NEMALIALES						
Family Galaxauraceae						
<i>Actinotrichia fragilis</i> (Forsskål) Børgesen					+	
Family Liagoraceae						
<i>Liagora ceranoides</i> J.V. Lamouroux				+		
Order GELIDIALES						
Family Gelidiaceae						
<i>Gelidium pusillum</i> (Stackhouse) Le Jolis		++		+		
Family Gelidiellaceae						
<i>Gelidiella acerosa</i> (Forsskål) Feldmann et G. Hamel	++					++

Table (Continued)

ID	WA	UI	MI	LJ	US	Comments
<i>Parviphyicus adnatus</i> (E.Y. Dawson) B. Santelices		++	++			
<i>Parviphyicus pannosus</i> (Feldmann) G. Furnari		++	+++			
Order HALYMENIALES						
Family Halymeniaceae						
<i>Grateloupia filicina</i> (J.V. Lamouroux) C. Agardh					+	
<i>Halymenia maculata</i> J. Agardh	++				++	
Order PEYSSONNELIALES						
Family Peyssonneliaceae						
<i>Peyssonnelia conchicola</i> Piccone et Grunow			+++		++	Grows in shaded sites
<i>Peyssonnelia rubra</i> (Greville) J. Agardh			+			
Order HILDENBRANDIALES						
Family Hildenbrandiaceae						
<i>Hildenbrandia rubra</i> (Sommerfelt) Meneghini		+	+++			
Order CORALLINIALES						
Family Corallinaceae						
<i>Amphiroa foliacea</i> J.V. Lamouroux					++	
<i>Amphiroa fragilisima</i> (Linnaeus) J.V. Lamouroux				+		
<i>Hydrolithon boreale</i> (Foslie) Y.M. Chamberlain					+	E – epiphyte on <i>Valonia ventricosa</i>
<i>Hydrolithon farinosum</i> (J.V. Lamouroux) Penrose et Y.M. Chamberlain			+ E ₁	+ E ₂	+ E ₃	E ₁ – epiphyte on <i>Cladophora lactevirens</i> , E ₂ – epiphyte on <i>P. japonica</i> var. <i>saxatieri</i> , E ₃ – epiphyte on <i>Hyphnea valentiae</i>
<i>Jania adhaerens</i> J.V. Lamouroux	+ E ₁			+	+ E ₂	E ₁ – epiphyte on <i>H. clathratus</i>
<i>Jania capillacea</i> Harvey	+		+++	+	++	In association with <i>Centroceras clavulatum</i>
<i>Jania pumila</i> J.V. Lamouroux					+	E – epiphyte on <i>Padina boryana</i>

Table (Continued)

ID	WA	UI	MI	LJ	US	Comments
<i>Pneophyllum fragile</i> Kützing	+ E _{1,3}			+ E ₂	+ E ₃	E ₁ – epiphyte on <i>V. ventricosa</i> ; E ₂ – epiphyte on <i>P. japonica</i> var. <i>saccharieri</i> ; E ₃ – epiphyte on <i>Lyngbya majuscula</i>
Order GIGARTINALES						
Family Cystocloniaceae						
<i>Hypnea pannosa</i> J. Agardh	++				+++	
<i>Hypnea spinella</i> (C. Agardh) Kützing	+ E ₁		++	+		E ₁ – epiphyte on <i>Hydroclatrus clatratius</i> ; E ₂ – epiphyte on <i>Palisada perforata</i>
<i>Hypnea valentiae</i> (Turner) Montagne			+	++	+++	
Order RHODYMENIALES						
Family Champiaceae						
<i>Champia parvula</i> (C. Agardh) Harvey						E ₁ – epiphyte on <i>S. polycystum</i> ; epibiont on hydroids
<i>Champia vieillardii</i> Kützing		+				
Family Lomentariaceae						
<i>Ceratodictyon intricatum</i> (C. Agardh) R.E. Norris			+			
<i>Ceratodictyon spongiosum</i> Zanardini	+			++		
<i>Lomentaria corallicola</i> Børgesen		++	+	++		
Order GRACILARIALES						
Family Gracilariaceae						
<i>Gracilaria edulis</i> (S.G. Gmelin) P.C. Silva				+		
<i>Gracilaria eucheumatoides</i> Harvey				++		+
<i>Gracilaria salicornia</i> (C. Agardh) E.Y. Dawson				+		+
<i>Gracilaria tenuistipitata</i> C.F. Chang et B.M. Xia			+			+

Table (Continued)

ID	WA	UI	MI	LI	US	Comments
Order CERAMIALES						
Family Ceramiaceae						
<i>Centroceras clavulatum</i> (C. Agardh) Montagne	+ E ₁		++	+	+ E ₂	E ₁ – epiphyte on <i>H. spinella</i> ; E ₂ – epiphyte on <i>S. polycystum</i>
<i>Centroceras minutum</i> Yamada				++ E		E – epiphyte on <i>P. perforata</i>
** <i>Ceramium borneense</i> Weber-van Bosse					++ E _{1,2}	E ₁ – epiphyte on <i>S. polycystum</i> ; E ₂ – epiphyte on <i>Hypnea pinnosa</i>
<i>Ceramium camouii</i> E.Y. Dawson			++			In association with <i>Centroceras clavulatum</i>
<i>Ceramium cimbrium</i> H.E. Petersen			S		+	
<i>Ceramium cingulatum</i> Weber-van Bosse				+		
<i>Ceramium comptum</i> Børgesen					++ E	E – epiphyte on <i>S. polycystum</i>
<i>Ceramium macilentum</i> J. Agardh			+			
** <i>Ceramium marshallense</i> E.Y. Dawson					+ E	E – epiphyte on <i>Dictyota friabilis</i>
<i>Ceramium tenerrimum</i> (G. Martens) Okamura					+ E	E – epiphyte on <i>S. polycystum</i>
<i>Ceramium vagans</i> P.C. Silva			+			
<i>Corallophila kleiwegii</i> Weber-van Bosse				+	+ E	E – epiphyte on <i>S. polycystum</i>
<i>Gayliella flaccida</i> (Harvey ex Kürzing) T.O. Cho et L.J. McIlvor			+ E ₁	++	++ E _{1,2}	E ₁ – epiphyte on <i>P. boryana</i> ; E ₂ – epiphyte on <i>S. polycystum</i>
Family Rhodomelaceae						
<i>Acanthophora muscoides</i> (Linnaeus) Bory				++		
<i>Acanthophora spicifera</i> (M. Vahl) Børgesen	++			+++ D	++	D – dominant
<i>Herposiphonia parva</i> Setchell			S			

Table (Continued)

ID	WA	UI	MI	LI	US	Comments
<i>Herposiphonia secunda</i> (C. Agardh) Ambronn	+		+		+ E	E – epiphyte on <i>S. polycystum</i>
<i>Herposiphonia secunda</i> f. <i>tenella</i> (C. Agardh) M.J. Wynne			++	+	+ E	E – epiphyte on <i>Dictyota implexa</i>
<i>Leveillea jungermanniioides</i> (K. Hering et G. Martens) Harvey	+			+	+ E	E – epiphyte on <i>S. polycystum</i>
<i>Neosiphonia ferulacea</i> (Suhr ex J. Agardh) S.M. Guimarães et M.T. Fujii					+ E	E – epiphyte on <i>P. boryana</i>
<i>Palisada perforata</i> (Bory) K.W. Nam [= <i>Laurencia papillosa</i> (C. Agardh) Greville; <i>Chondrophycus papillosus</i> (C. Agardh) D.J. Garbary et J.T. Harper; <i>Palisada papillosa</i> (C. Agardh) K.W. Nam]			+++	+++ D		D – dominant
** <i>Polysiphonia japonica</i> var. <i>saxatieri</i> (Hariot) Yoon			+++		++ E	E – epiphyte on <i>S. polycystum</i>
<i>Polysiphonia subtilissima</i> Montagne			+			
<i>Tolyptocladia glomerulata</i> (C. Agardh) F. Schmitz	+		+	+++ D	++ E	E – epiphyte on <i>S. Polycystum</i> ; D – dominant
Family Wrangeliaceae						
<i>Anotrichium tenue</i> (C. Agardh) Nägeli					+ E	E – epiphyte on <i>S. polycystum</i>
<i>Griffithsia metacalfii</i> C.K. Tseng					+	
<i>Griffithsia rhizophora</i> Grunow ex Weber-van Bosse				+	+	
<i>Wrangelia argus</i> (Montagne) Montagne					+	
Family Spyridiaceae						
<i>Spyridia filamentosa</i> (Wulfen) Harvey		+		++	++	

Table (Continued)

ID	WA	UI	MI	LI	US	Comments
OCHROPHYTA						
Order ECTOCARPALES						
Family Acinetosporaceae						
<i>Feldmannia mitchelliae</i> (Harvey) H.-S. Kim	+			++ E _{1,2}	+ E ₃	E ₁ – epiphyte on <i>S. polycystum</i> ; E ₂ – epiphyte on <i>Turbinaria ornata</i> ; E ₃ – epiphyte on <i>Padina boryana</i>
Family Chordariaceae						
<i>Kuetzingiella elachistaeformis</i> (Heydrich) M. Balakrishnan et Kinkar			+	++		
Family Scytosiphonaceae						
<i>Chnoospora implexa</i> J. Agardh	+				++	
<i>Colpomenia sinuosa</i> (Mertens ex Roth) Derbès et Solier	++					
<i>Hydroclathrus clathratus</i> (C. Agardh) M.A. Howe	+ E			++	+	E – epiphyte on <i>Palisada papillosa</i>
<i>Hydroclathrus tenuis</i> C.K. Tseng et Lu				+		
<i>Rosenvingeia intricata</i> (J. Agardh) Børgesen	+					
Order RALFSIALES						
Family Neoralfsiaceae						
<i>Neoralfsia expansa</i> (J. Agardh) P.-E. Lim et H. Kawai ex Cormaci et G. Furnari		+++				
Order SPHACELARIALES						
Family Sphacelariaceae						
<i>Sphacelaria novae-hollandiae</i> Sonder			++	++ E	+	E – epiphyte on <i>P. boryana</i>
<i>Sphacelaria rigidula</i> Kützting		+	+			
<i>Sphacelaria tribuloides</i> Meneghini			+		++ E	E – epiphyte on <i>S. polycystum</i>

Table (Continued)

ID	WA	UI	MI	LJ	US	Comments
Order DICTYOTALES						
Family Dictyotaceae						
<i>Canistrocarpus cervicornis</i> (Kützinger) De Paula et De Clerck				+		
<i>Dictyota bartayresiana</i> J.V. Lamouroux					+	
<i>Dictyota friabilis</i> Setchell	+					
<i>Dictyota implexa</i> (Desfontaines) J.V. Lamouroux	+			+	++	
<i>Lobophora variegata</i> (J.V. Lamouroux) Womersley ex Oliveira	+		+	++	+	
<i>Padina australis</i> Hauck				+		
<i>Padina boryana</i> Thivy	++	+	+	++	++	
Order FUCALES						
Family Sargassaceae						
<i>Sargassum ilicifolium</i> (Turner) C. Agardh					+++	
<i>Sargassum mclurei</i> Setchell	+					
<i>Sargassum oligocystum</i> Montagne	+					
<i>Sargassum polycystum</i> C. Agardh	+			+	+++	
<i>Turbinaria ornata</i> (Turner) J. Agardh	+			+	+	
CHLOROPHYTA						
Order ULOTRICHIALES						
Family Ulotrichaceae						
<i>Ulothrix implexa</i> (Kützinger) Kützinger					+ E	E – epiphyte on <i>Polysiphonia japonica</i> var. <i>savatierei</i>

Table (Continued)

ID	WA	UI	MI	LI	US	Comments
Order ULVALES						
Family Ulvellaceae						
<i>Ulvea geniculata</i> (N.L. Gardner) R. Nielsen, C.J. O'Kelly et B. Wysox [= <i>Pseudodictyon geniculatum</i> N.L. Gardner]			+ En _{1,2}	+ En ₃		En ₁ – endophyte of <i>Hypnea spinella</i> ; En ₂ – endophyte of <i>Ceramium camoui</i> ; En ₃ – <i>Polysiphonia japonica</i> var. <i>savatierei</i>
<i>Ulvea lens</i> P. Crouan et H. Crouan					+ E	E – epiphyte on <i>V. ventricosa</i>
<i>Ulvea leptochaete</i> (Huber) R. Nielsen, C.J. O'Kelly et B. Wysox				+ En ₁	+ En ₂	En ₁ – endophyte of <i>P. japonica</i> var. <i>Savatierei</i> ; En ₂ – endophyte of <i>V. ventricosa</i>
<i>Ulvea viridis</i> (Reinke) R. Nielsen, C.J. O'Kelly et B. Wysox					+ E _{1,2}	E ₁ – epiphyte on <i>Valonia ventricosa</i> ; E ₂ – epiphyte on <i>Centroceras clavulatum</i>
Family Ulvaceae						
<i>Ulva clathrata</i> (Roth) C. Agardh	+++		+++	+++		
<i>Ulva compressa</i> Linnaeus			+ E			E – epiphyte on <i>C. clavulatum</i>
<i>Ulva lactuca</i> Linnaeus [= <i>Ulva fasciata</i> Delile]	+++	+++				
Order CLADOPHORALES						
Family Cladophoraceae						
<i>Chaetomorpha linum</i> (O.F. Müller) Kützting			+	+	+	
<i>Cladophora laetevirens</i> (Dillwyn) Kützting	+	+	++	+++	+ E	E – epiphyte on <i>S. polycystum</i>
<i>Rhizoclonium riparium</i> (Roth) Harvey			+	+		
<i>Rhizoclonium riparium</i> var. <i>implexum</i> (Dillwyn) Rosenvinge	+	+	+++ E ₁	+	+ E ₂	E ₁ – epiphyte on <i>G. pusillum</i> ; E ₂ – epiphyte on <i>S. polycystum</i>
Family Pseudocladophoraceae						
<i>Pseudocladophora horii</i> (C. Hoek et Chihara) Boedeker et Leliaert			+			E – epiphyte on <i>P. perforata</i>

Table (Continued)

ID	WA	UI	MI	LJ	US	Comments
Family Anadyomenaceae						
<i>Anadyomene wrightii</i> Harvey ex J.E. Gray	+				+	
Family Boodleaceae						
<i>Boodlea composita</i> (Harvey) F. Brand			+	++	++	In association with <i>G. pusillum</i>
<i>Cladophoropsis sundanensis</i> Reinbold		+	+			
<i>Phylloclityon anastomosans</i> (Harvey) Kraft et M.J. Wynne				+	+	
Family Siphonocladaceae						
<i>Dichysphaeria cavernosa</i> (Forsskål) Børgesen			+	+		
Family Valoniaceae						
<i>Valonia ventricosa</i> J. Agardh					+	
Order DASYCLADALES						
Family Dasycladaceae						
<i>Bornetella oligospora</i> Solms-Laubach			+	+	++	
<i>Bornetella sphaerica</i> (Zanardini) Solms-Laubach					++	
<i>Neomeris annulata</i> Dickie				+	++	
Family Polyphysaceae						
<i>Parvocaulis clavatus</i> (Yamada) S. Berger, U. Fettweiss, S. Gleissberg, L.B. Liddle, U. Richter, H. Sawitzky et G.C. Zuccarello			++			
<i>Parvocaulis exiguus</i> (Solms-Laubach) S. Berger, Fettweiss, Gleissberg, Liddle, U. Richter, Sawitzky et Zuccarello			++	+	+	
<i>Parvocaulis parvulus</i> (Solms-Laubach) S. Berger, Fettweiss, Gleissberg, Liddle, U. Richter, Sawitzky et Zuccarello			+	+	+	

Table (Continued)

ID	WA	UI	MI	LI	US	Comments
Order BRYOPSIDALES						
Family Bryopsidaceae						
<i>Bryopsis pennata</i> J.V. Lamouroux				+	++	
Family Caulerpaceae						
<i>Caulerpa serrulata</i> (Forskål) J. Agardh				++	++	
<i>Caulerpella ambigua</i> (Okamura) Prud'Homme van Reine et Lokhorst					+	
Family Udoteaceae						
<i>Penicillus sibogae</i> A. Gepp et E.S. Gepp			+			
<i>Rhipidosiphon javensis</i> Montagne					++	
CYANOBACTERIA						
Order OSCILLATORIALES						
Family Oscillatoriaceae						
<i>Lyngbya aestuarii</i> Liebman ex Gomont			+	+		
* <i>Lyngbya majuscula</i> Harvey ex Gomont	+	++	+++	+++	+	
* <i>Lyngbya semiplena</i> J. Agardh ex Gomont		++		+		
* <i>Lyngbya sordida</i> Gomont					+	
* <i>Oscillatoria bonnemaisonii</i> P. Crouan et H. Crouan ex Gomont	+					
<i>Oscillatoria limosa</i> C. Agardh ex Gomont				+	+	
* <i>Phormidium nigroviride</i> (Thwaites ex Gomont) Anagnostidis et Komárek			+			
<i>Phormidium</i> sp.				+		

Table (Continued)

ID	WA	UI	MI	LJ	US	Comments
Family Coleofasciculaceae						
* <i>Coleofasciculus chthonoplastes</i> (Thuret ex Gomont) M. Siegesmund, J.R. Johansen et T. Friedl						
Family Microcoleaceae						
<i>Microcoleus</i> sp.						
* <i>Planktothrix agardhii</i> (Gomont) Anagnostidis et Komárek [= <i>Oscillatoria agardhii</i> Gomont]						
Order NOSTOCALES						
Family Rivulariaceae						
* <i>Calothrix confervicola</i> C. Agardh ex Bornet et Flahault						
						E – epiphyte on <i>Polysiphonia subtilissima</i>
Order SPIRULINALES						
Family Spirulinaceae						
<i>Spirulina major</i> Kützing ex Gomont						
* <i>Spirulina subtilissima</i> Kützing ex Gomont						
BACILLARIOPHYTA						
Order LICMOPHORALES						
Family Licmophoraceae						
<i>Licmophora</i> sp.						
						E – epiphyte on <i>Lyngbya majuscula</i>

Notes. ID – species identification; WA – washed ashore; UI – upper intertidal; MI – middle intertidal; LJ – lower intertidal; US – upper subtidal; E – epiphyte; En – endophyte; Ep – epibiont; D – dominant; + – rare (<10% of the projective surface of the bottom, PSB); ++ – common (from 10 to 30% of the PSB); +++ – abundant (>30–50% of the PSB).

*Species new for Hainan Island.

**Species new for China.

An algal community was defined as mono-dominant if one algal species occupied more than 50% of the bottom surface area where the community occurred. In a bidominant community, two species occupied more than 50% of the bottom surface area. Other communities were defined as polydominant.

Results

The results of the floristic analysis of algal communities in the intertidal and upper subtidal zones of the Luhuitou reef are presented in Table. Algae were not found in the splash zone. In the upper, middle and lower intertidal zones hard substrates (stones, dead coral colonies, carbonate basis of the reef) were occupied by macroalgae and cyanobacteria. In the upper subtidal zone, scleractinian corals covered the bottom up to 10–50%. Macroalgae, cyanobacteria and diatoms commonly occupied the rest of the hard substrates in the upper subtidal zone.

A total of 137 species were found in April 2009 at the Luhuitou reef (see Table) including 30 species of Chlorophyta (Ch), 23 species of Phaeophyceae (Ph), 69 species of Rhodophyta (Rh), 14 species of Cyanobacteria (Cy) and 1 species of Bacillariophyta (Ba). Chlorophyta were presented by 5 orders including 13 families, Phaeophyceae were presented by 6 orders, including 6 families, Rhodophyta by 14 orders and 20 families, Cyanobacteria by 3 orders and 4 families, and Bacillariophyta by 1 order including 1 family. Three species of the red algae *Ceramium marshallense* E.Y. Dawson, *Ceramium borneense* Weber-van Bosse, *Polysiphonia japonica* var. *savatieri* (Hariot) Yoon are new records for China, *Acanthophora muscoides* (Linnaeus) Bory (Rh), and 9 species of Cyanobacteria are new records for Hainan Island.

In the intertidal zone, macroalgae formed two types of communities: a mono-dominant community of crust algae and monodominant, bidominant or polydominant communities of turf-forming algae. In the upper subtidal zone, polydominant communities of macroalgae prevailed. The substrate in the upper intertidal zone was represented mainly by gravel and boulders consisting of stones, coral blocks and debris.

In the upper intertidal zone large coral boulders were occupied by a mono-dominant community of the crust alga *Neoralfsia expansa* (J. Agardh) P.-E. Lim et H. Kawai ex Kraft and by monodominant communities of algal turf with the dominance of the red alga *Lomentaria corallicola* Børgesen and the green alga *Ulva clathrata* (Roth) C. Agardh (Fig. 2).

Accompanying species in the algal turf community of *L. corallicola* were represented by the green alga *Cladophora laetevirens* (Dillwyn) Kützinger, by the red



Fig. 2. Upper intertidal zone. The upper right insert shows the community of the red alga *Lomentaria corallicola*, the lower one shows the community of the green alga *Ulva clathrata*.

algae *Parviphycus adnatus* (E.Y. Dawson) B. Santelices and *Gelidium pusillum* var. *cylindricum* W.R. Taylor, and by the blue-green algae *Lyngbya semiplena* J. Agardh ex Gomont and *L. majuscula* Harvey ex Gomont. The surf zone was represented by the belt (50 cm wide and 5 cm thick) of washed ashore algae among which *Ulva lactuca* Linnaeus was a dominant species and *Acanthophora spicifera* (M. Vahl) Børgesen, *Hypnea pannosa* J. Agardh, *Halymenia maculata* J. Agardh, *Gelidiella acerosa* (Forsskål) Feldmann et G. Hamel, *Padina boryana* Thivy, etc. were common.

In the middle intertidal zone, the algal turf community was dominated by *Polysiphonia japonica* var. *savatieri*, which mainly occupied the flat carbonate reef basis (Fig. 3).

The red algae *Herposiphonia secunda* f. *tenella* (C. Agardh) M.J. Wynne, *Hypnea spinella* (C. Agardh) Kützinger, *Spyridia filamentosa* (Wulfen) Harvey, *Centroceras clavulatum* (C. Agardh) Montagne and *Jania capillacea* Harvey were common among the bed of *P. japonica* var. *savatieri*.

A monodominant community of *U. clathrata* occupied large boulders (Fig. 4), where the main accompanying species were *P. adnatus*, *H. secunda* f. *tenella*, *P. japonica* var. *savatieri*, and *Ceramium camouii* E.Y. Dawson.

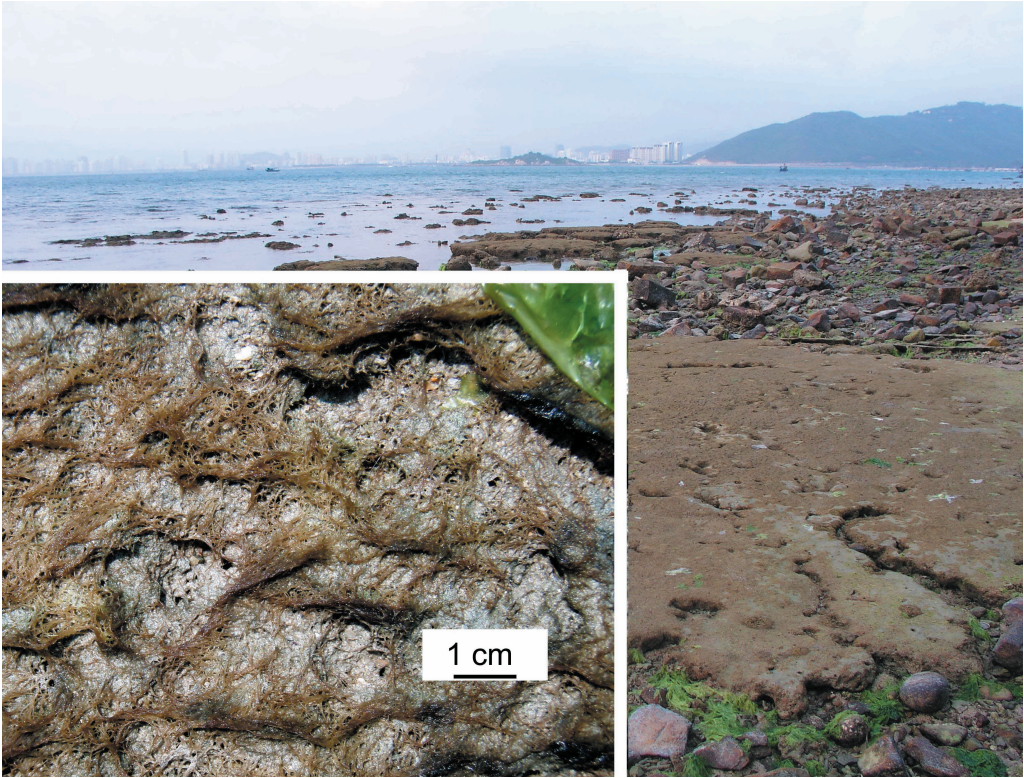


Fig. 3. Middle intertidal zone, the algal turf community dominated by *Polysiphonia japonica* var. *savatieri*, occupying mainly the basis of a flat carbonate reef.

At the border between the lower intertidal and mid-intertidal zones, mainly a bidominant community of *U. clathrata* and *C. laetevirens* (Ch) occupied the reef basis, where *U. fasciata* (Ch) and *Palisada perforata* (Bory) K.W. Nam (Rh) were common species (Fig. 5).

In the middle intertidal zone, a monodominant community of the crust red alga *Hildenbrandia rubra* (Sommerfelt) Meneghini was common on the upper surfaces of stones (Fig. 6).

On the shaded surface of the coral boulders, a monodominant community of the red crust alga *Lithothamnion* sp. was common.

The low intertidal zone was commonly occupied by turf algal communities, where *A. spicifera*, *P. perforata*, *Tolypocladia glomerulata* (C. Agardh) F. Schmitz (Rh) dominated (Fig. 7). Furthermore, the algae such as *A. muscoides*, *Hypnea valentiae* (Turner) Montagne, *Gracilaria eucheumatoides* Harvey, *S. filamentosa*, *Gayliella flaccida* (Harvey ex Kützing) T.O. Cho et L.J. McIvor (Rh), *Colpomenia sinuosa* (Mertens ex

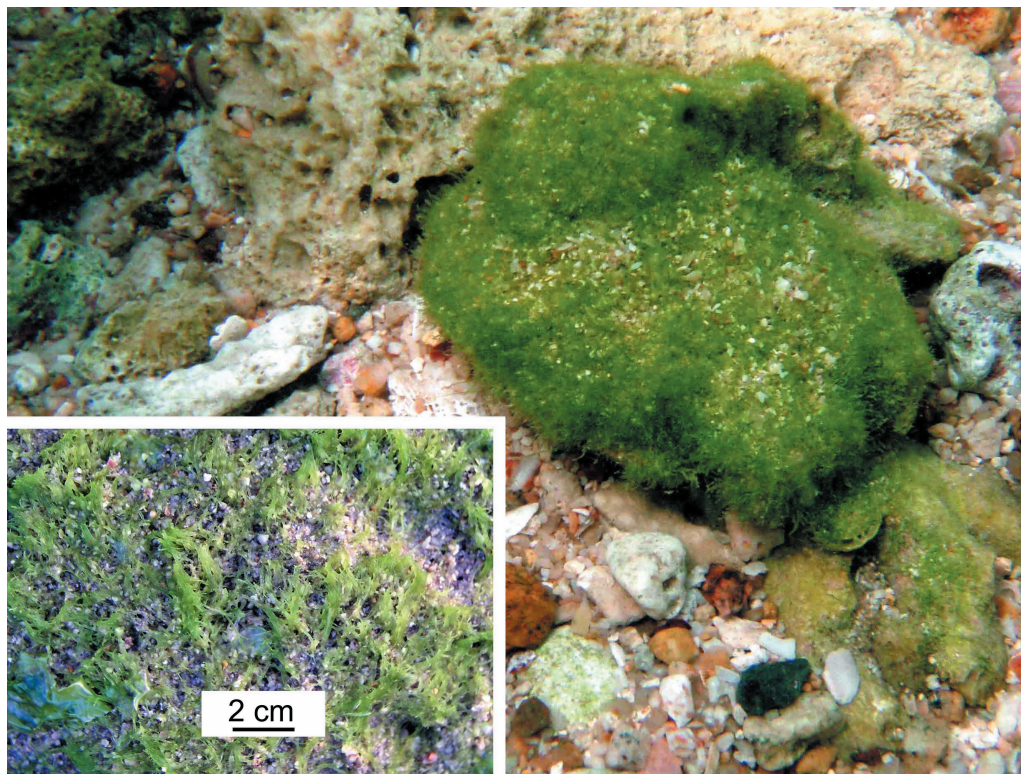


Fig. 4. Middle intertidal zone, the community of *Ulva clathrata*.

Roth) Derbès et Solier, *Hydroclathrus clathratus* (C. Agardh) M.A. Howe, *P. boryana* (Ph), *Boodlea composita* (Harvey) F. Brand, *Caulerpa serrulata* (Forsskål) J. Agardh (Ch) were also common.

Communities of Cyanobacteria often covered the algal turf communities, where *Planktothrix agardhii* (Gomont) Anagnostidis et Komárek (= *Oscillatoria agardhii*) and *L. majuscula* (Cy) were dominant (Fig. 8).

In the upper subtidal zone, two algal communities were found: a bidominant community of the brown frondose algae *Sargassum polycystum* C. Agardh and *S. ilicifolium* (Turner) C. Agardh (Fig. 9). At the edge of the community *Sargassum* bed, *S. polycystum* was densely overgrown by epiphytes, such as *Acrochaetium robustum* Børgesen, *Centroceras clavulatum* (C. Agardh) Montagne, *G. flaccida*, *Ceramium comptum* Børgesen, *C. borneense*, *P. japonica* var. *savatieri* (Rh), *Feldmannia mitchelliae* (Harvey) H.-S. Kim, *Sphacelaria tribuloides* Meneghini (Ph). The community was distributed along the foreshore at the border between the low intertidal and upper subtidal zones.

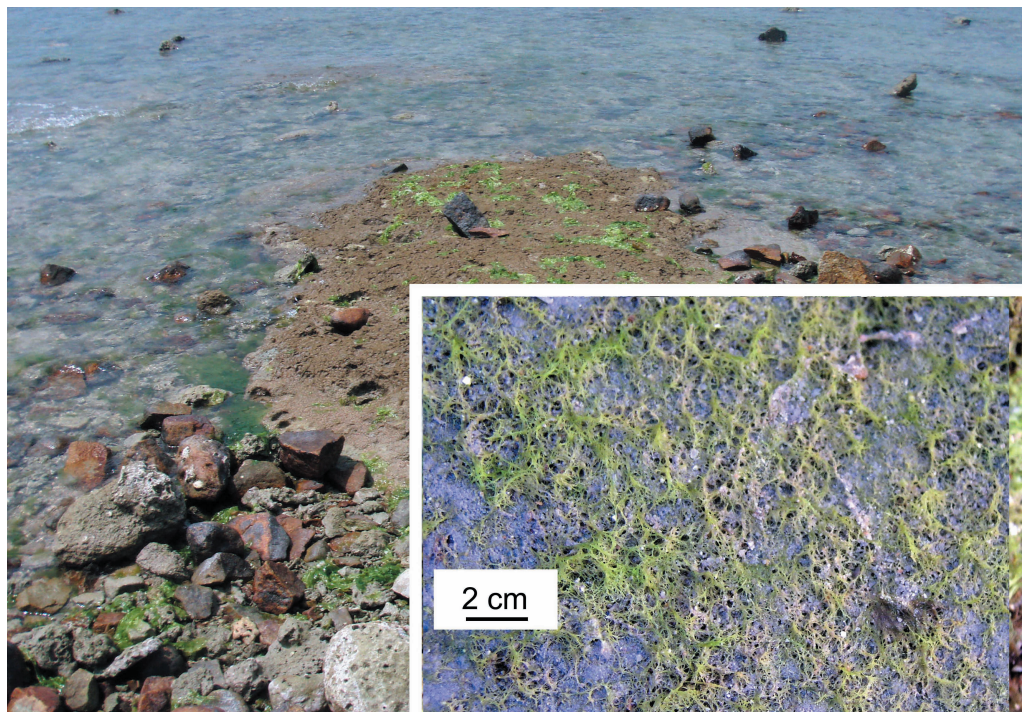


Fig. 5. Middle intertidal zone, the bidominant community of *Ulva clathrata* and *Cladophora laetevirens*.

Behind the bed of *Sargassum* species, the hard substrate consisted of patch reef debris and was occupied by a polydominant community of turf algae. In the turf, *A. spicifera*, *Amphiroa foliacea* J.V. Lamouroux, *Ceratodictyon spongiosum* Zanardini, *G. acerosa*, *H. maculata*, *Jania capillacea* Harvey, *Peyssonnelia conchicola* Piccone et Grunow, *T. glomerulata* (Rh), *Dictyota friabilis* Setchell, *Padina boryana* (Ph), *B. oligospora*, *B. sphaerica*, *Boodlea composita* (Harvey) F. Brand, *Bryopsis pennata* J.V. Lamouroux, *C. serrulata*, *Neomeris annulata* Dickie (Ch) were common.

Scleractinian corals belongin to the genera *Porites*, *Acropora*, *Pocillopora*, *Stylophora*, *Montipora*, etc. were also common in the upper subtidal zone (Fig. 10).

Discussion

According to the floristic analysis conducted in the intertidal and upper subtidal zones of the Luhuitou reef, marine macroalgae occupied mostly hard substrates (rocky bottom, carbonate reef basis, dead coral colonies and their debris). Living scleractinian corals were observed as patch reefs or in between algal turf only in

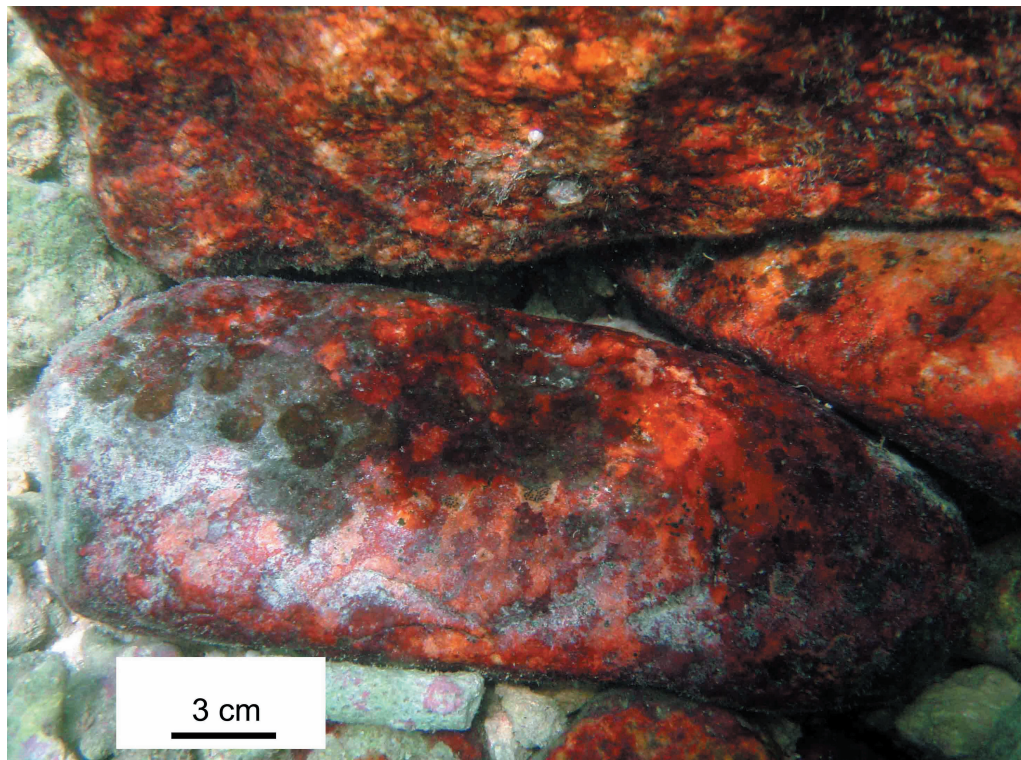


Fig. 6. Middle intertidal zone, the monodominant community of the crust red alga *Hildenbrandia rubra*.

the upper subtidal zone. Intertidal algal communities were mainly represented by algal turf and crust algae. In the subtidal zone, fleshy, frondose and foliose algae enriched algal turf communities. *Sargassum* spp. community occupied the upper border of the subtidal zone.

Filamentous finely branched, red and green algae formed algal turf. In the upper intertidal zone, these species were represented by *Lomentaria corallicola* Børgesen (Rh) and *U. clathrata* (Ch); in the middle intertidal zone by *P. japonica* var. *savatieri*, *Palisada perforata*, *Parviphycus pannosus* (Rh), *U. clathrata* and *Cladophora laetevirens* (Ch); in the low intertidal zone by *Acanthophora spicifera*, *P. perforata* and *Tolyptocladia glomerulata* (Rh). In the upper subtidal zone, a community of frondose and fleshy algae was dominated by *Sargassum polycystum*, *S. ilicifolium*, *Lobophora variegata*, *Padina boryana* (Ph), *Hypnea pannosa*, and *H. valentiae* (Rh). Moreover, skeletons of dead corals were overgrown by algal turf consisting of dominant species such as *T. glomerulata*, *Centroceras clavulatum*, *Gayliella flaccida*, *Herposiphonia secunda* f. *tenella* (Rh), *Sphacelaria novae-hollandiae* (Ph).

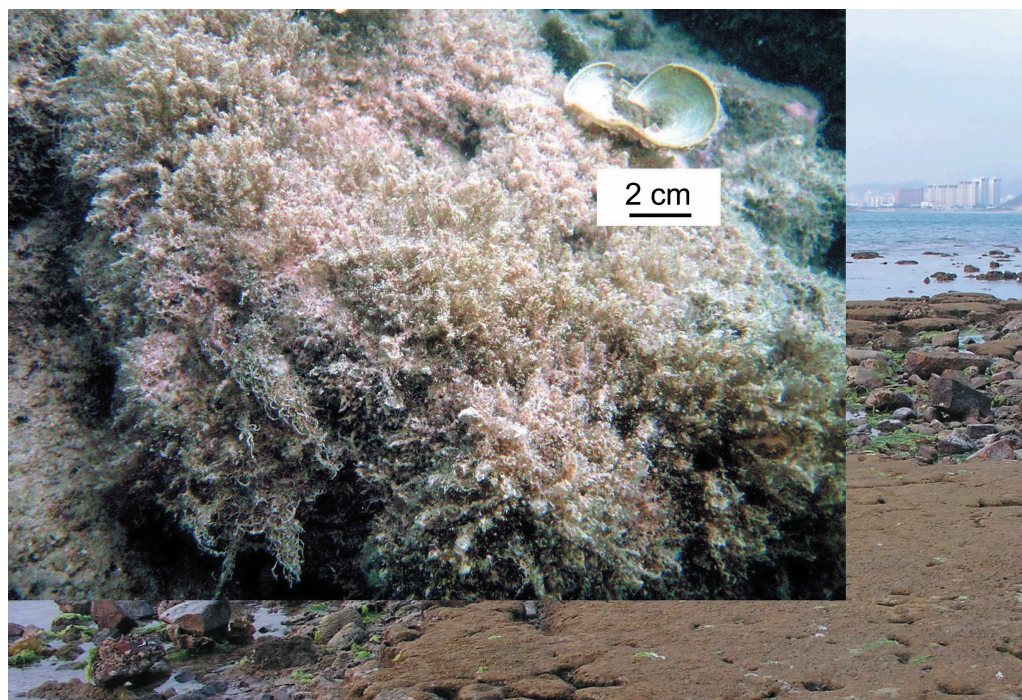


Fig. 7. Lower intertidal zone, turf algal communities with domination of *Acanthophora spicifera*, *Palisada perforata*, *Tolypocladia glomerulata*.

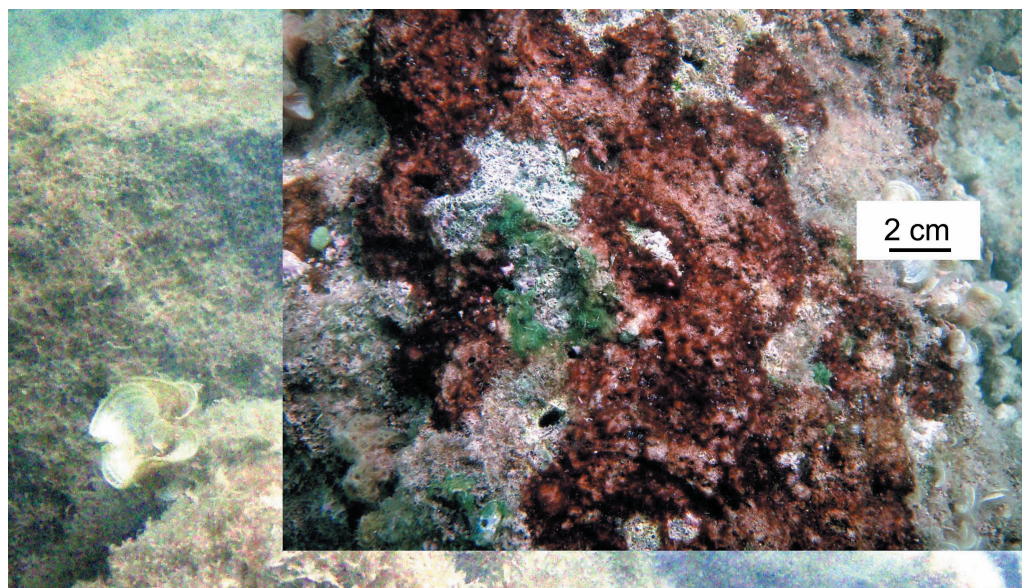


Fig. 8. Lower intertidal zone, the community of Cyanobacteria.

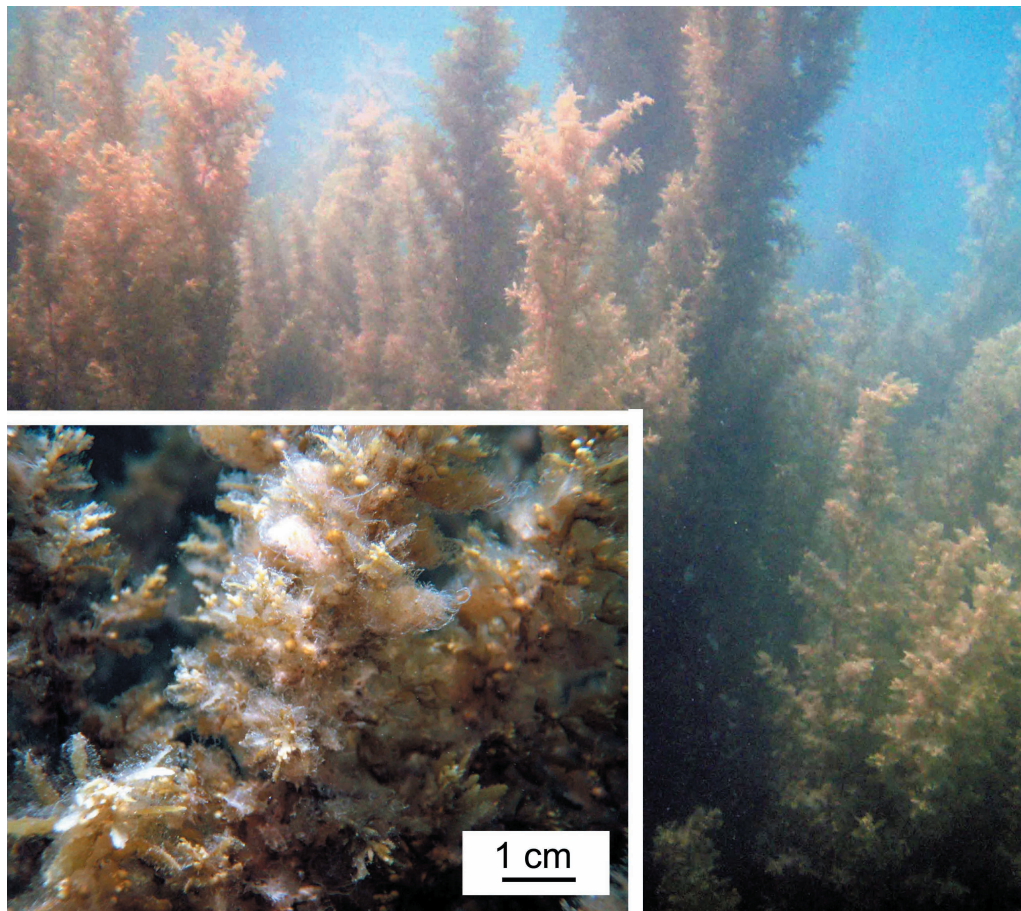


Fig. 9. Upper subtidal zone, the community of *Sargassum* spp. Insert: *Sargassum polycystum*.

The number of red algae species was highest at the locations investigated. At the same time, brown algae such as *Sargassum* spp. had the highest total biomass. Algae were rarely washed ashore. The algal beach wracks consisted of lower intertidal and upper subtidal attached algae inhabiting the reef investigated. There were no invasive species in the investigated area. We did not observe superabundant large frondose macroalgae, such as *Sargassum* spp., *Lobophora variegata*, *Dictyota* spp., *Halimeda* spp. that were reported by Lapointe et al. (1997) as the species widely distributed over nutrient enriched reefs in Jamaica. However, at the Luhuitou reef site, we observed epiphyte blooms, especially common for the macroalgae such as *Sargassum* spp., *Padina* spp., and *Dictyota* spp. We suggest that the species composition and biomass of macroalgae and their epiphytes, as well as those of cyano-

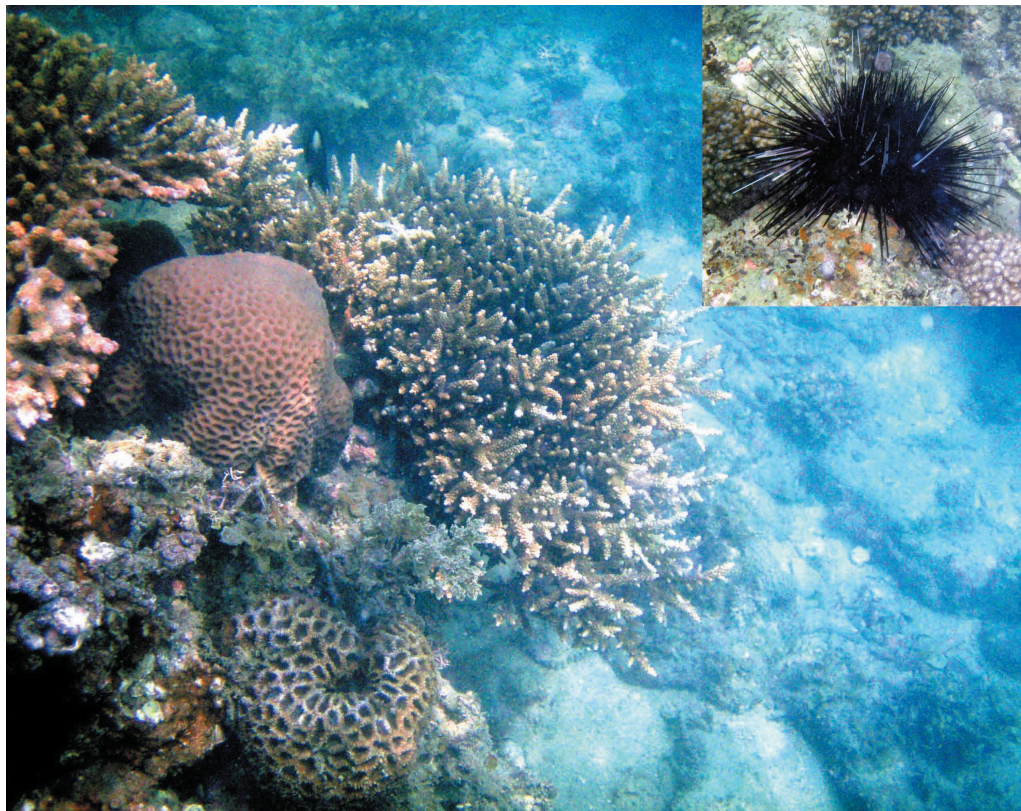


Fig. 10. Upper subtidal zone, scleractinian corals of the genera *Porites*, *Acropora*, *Stylophora*, *Montipora*.

bacteria and corals on the Luhuitou reef are controlled by the impact of predators and availability of resources (“top-down” and “bottom-up”) (Atkinson, Grigg, 1984; Carpenter et al., 1985; Littler et al., 2006). We consider that during the time of this study, Luhuitou reef was in a steady-state condition and adapted to the increased concentrations of nitrogen and phosphorus substances.

Floristic survey at the Luhuitou reef showed that this site is occupied by algal communities and algal species that are typical for tropical coral reefs. Thus, the Luhuitou reef by the nature of its algal communities (turf, crusts, frondose fleshy algal communities, temporary communities of Cyanobacteria), composition of macroalgae and Cyanobacteria and the projective surface area of the bottom occupied by algal communities, is similar to that of damaged coral reefs of Australia (Diaz-Pulido, McCook, 2002), Okinawa (Titlyanov et al., 2008) and Con Dao Islands, Vietnam (Titlyanov, Titlyanova, unpublished data).

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Heterobranch mollusks of the orders Acteonoidea and Cephalaspidea (Gastropoda: Heterobranchia) of Vietnam: annotated check-list with illustrations of some species

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Abstract: The paper presents an annotated check-list of heterobranch gastropods of the orders Acteonoidea and Cephalaspidea of Vietnam, based on the own unpublished data and data from other authors, with taxonomical notes and photos of some taxons. The list contains 65 species. Families Retusidae and Scaphandridae and 13 species are new for the fauna of Vietnam. A new subfamily Semiretusinae Chaban **subfam. nov.** (Cylichnidae H. et A. Adams, 1854) has been erected for the genus *Semiretusa* Thiele, 1925 based on the morphology of its radula and gizzard plates.

Key words: heterobranch Gastropoda, Acteonoidea, Cephalaspidea, Vietnam, fauna, taxonomy, new subfamily.

Until the middle of the 20th century the cephalaspids of Vietnam were represented in the literature by 10 species from 6 families (Serène, 1937; Dawydoff, 1952). However, a great deal of material was collected during the second half of the 20th century and deposited in research institutes of Vietnam (Nguen X. Duc et al., 1997; Hylleberg, Kilburn, 2003). Based on these collections, a list of cephalaspids has reached 38 species from 9 families (Nguen X. Duc et al., 1997; Nguen X. Duc, 2001; Hylleberg, Kilburn, 2003 (Opisthobtanchia annotated by K.R. Jensen); Thach, 2005, 2007). Some of these species were illustrated (Thach, 2005, 2007).

During the last ten years, several Russian scientists from Moscow, St. Petersburg and Vladivostok institutes took part in collecting and studying of opisthobranch malacofauna of Vietnam. Nine cephalaspid species new for Vietnam fauna were reported and illustrated, with excellent photos of brightly colored specimens (Martynov, Korshunova, 2012). To date, 53 species of Cephalaspidea s.l. (including Acteonoidea and Ringiculoidea) have been recorded from Vietnam. They are

predominantly from Acteonidae, Aplustridae, Haminoeidae, and Aglajidae families. Members of these families are generally large and colored, but uncolored and small specimens are less studied. An annotated check-list of species Cephalaspidea s.l. of Vietnam, based on data from the literature on Opisthobranchia and collections of the Zoological Institute, Russian Academy of Sciences is presented here with an emphasis on small forms. The specimens were collected during Russian-Vietnamese expedition in the Gulf of Tonkin in 1961, by Dr. Alexey Chernyshev in 2005 and 2007, and by Dr. Boris Sirenko in Vietnam from 1984 to 2015. According to Bouchet and Rocroi (2005), Acteonidae, Aplustridae and Ringiculidae are removed from the order Cephalaspidea now, but included in this work. Acteonoidea are represented by 15 species, Ringiculoidea by 2 species and Cephalaspidea s.s. by 49 species. Two families (Retusidae and Scaphandridae) and 13 species (indicated with asterisks) are new for the fauna of Vietnam. A new subfamily Semiretusiinae has been erected for *Semiretusa* Thiele, 1925 based on the morphology of its radula and gizzard plates. The taxa of Cephalaspidea s.s. are given here according to the taxonomic classification of Oskars et al. (2015).

Based on Thach's descriptions (Thach, 2005, 2007), *Pupa strigosa strigosa* (Gould, 1859) is excluded from the fauna of Vietnam, and *Pupa sekii* Habe, 1958 is added. *Haminoea* Leach in Gray, 1847 species were recorded by several authors mostly without studying their internal morphology, but the shell of *Haminoea* has so few taxonomically significant characters that the presence of the recorded *Haminoea* species in Vietnam needs confirmation in most cases.

Hylleberg and Kilburn (2003) did much work analyzing the voucher material deposited in research institutes of Vietnam and/or described in the literature. Their list consists of about 2200 species, and the authors noted: "In the majority of cases we have only judged the names given to species; not the actual specimens". This work therefore specifies the sources for the species from the Hylleberg and Kilburn's list (l.c.).

Here is the list of species of the family Ringiculidae and of the order Cephalaspidea collected from 1961 to 2015 in Vietnam and stored in the Zoological Institute RAS:

- | | |
|---|---|
| <i>Aliculastrum cylindricum</i> (Helbling, 1779) | * <i>Limulatys ooformis</i> Habe, 1952 |
| <i>Atys naucum</i> (L., 1758) | * <i>Limulatys muscarius</i> (Gould, 1859) |
| * <i>Atys semistriatus</i> Pease, 1860 | * <i>Micratys ovum</i> Habe, 1952 |
| <i>Bulla ampulla</i> L., 1758 | * <i>Micratys</i> cf. <i>wareni</i> Valdés, 2008 |
| <i>Cylichna biplicata</i> (A. Adams in Sowerby, 1850) | <i>Mnestia girardi</i> (Audouin, 1826) – comb. nov. |
| * <i>Diniatys dentifer</i> (A. Adams, 1850) | <i>Phanerophthalmus smaragdinus</i> (Rüppell et Leuckart, 1828) |
| <i>Liloa curta</i> (A. Adams, 1850) | |

**Philine otukai* Habe, 1946

Pseudophiline hayashii Habe, 1976

Philinorbis teramachii Habe, 1950

**Retusa concentrica* (A. Adams, 1850)

**Retusa waughiana* Hedley, 1899

**Ringicula kurodai* Takeyama, 1935

**Scaphander japonicus* A. Adams, 1862

Semiretusa borneensis (A. Adams, 1850)

**Tornatina koyasensis* Yokoyama, 1927

Systematic part

Informal Group “Lower **HETEROBRANCHIA**”

Superfamily **Acteonoidea** d’Orbigny, 1843

Family **Acteonidae** d’Orbigny, 1843

Genus *Acteon* Montfort, 1810

Acteon virgatus (Reeve, 1842)

Tornatella virgata Reeve, 1842a, p. 60.

Punctacteon virgatus (Reeve, 1842): Thach, 2005, p. 228, pl. 8, fig. 24.

Acteon virgatus (Reeve, 1842): Hylleberg, Kilburn, 2003, p. 117; Poppe, 2010, p. 42, pl. 712, figs. 6–8; Bouchet, 2014.

C o m m e n t s. The species was found on sand bottoms at 1–50 m depth (Thach, 2005).

Genus *Japonacteon* Taki, 1954

Japonacteon sieboldii (Reeve, 1842)

Tornatella sieboldii Reeve, 1842a, p. 61.

Actaeon sieboldii (Reeve, 1842): Pilsbry, 1893, p. 148, pl. 19, figs. 18, 19.

Acteon sieboldi (Reeve, 1842): Hori, 2000, p. 733, pl. 365, fig. 1.

Acteon sieboldii (Reeve, 1842): Thach, 2007, p. 159, fig. 861.

Japonacteon sieboldii (Reeve, 1842): Valdés, 2008, p. 601–604, figs. 6A–D, 7, 8A.

C o m m e n t s. The species was found on sand bottoms at 5–25 m depth (Thach, 2007).

Genus *Maxacteon* Rudman, 1971

Maxacteon fabreanus (Crosse, 1873)

Tornatella fabreana Crosse, 1873a, p. 66; 1873b, p. 130–131, pl. 5, fig. 4.

Pupa fabreana (Crosse, 1874): Hylleberg, Kilburn, 2003, p. 118.

Maxacteon fabreanus (Crosse, 1874): Valdés, 2008, p. 606.

Acteon fabreanus (Crosse, 1874): Poppe, 2010, p. 38, pl. 710, fig. 3.

C o m m e n t s. The species was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on collections of the Institute of Oceanography, Nha Trang.

Maxacteon flammeus (Gmelin, 1791)

Voluta flammea Gmelin, 1791, p. 3435.

Punctacteon flammeus (Gmelin, 1791): Hori, 2000, p. 733, pl. 365, fig. 7.

Maxacteon flammea (Gmelin, 1791): Hylleberg et Kilburn, 2003, p. 117.

Punctacteon kajiyamai Habe, 1976: Thach, 2007, p. 159, fig. 817 (not Habe, 1976).

Acteon flammeus (Gmelin, 1791): Poppe, 2010, p. 40, pl. 711, figs. 1–3.

C o m m e n t s. The species was found on sand bottoms at 1–10 m depth (Thach, 2007, as *Punctacteon kajiyamai*). It was listed by Thach (2007) as *P. kajiyamai*, but the figured specimen (l.c., 2007, p. 159, fig. 817) has discontinuous pink axial strips, characteristic for *Acteon flammeus* (Pilsbry, 1893; Rudman, 1998). *P. kajiyamai* is ornamented with brown wide continuous strips and yellow interspaces, similarly to *Acteon virgatus* (Reeve, 1842) (Habe, 1976a).

The original binomen of the species was mistakenly stated as *Buccinum flammeum* Bruguière, 1789 (Rosenberg, 2014). However, *B. flammeum* of Bruguière belongs to Nassariidae (Cernohorsky, 1984).

Genus *Punctacteon* Kuroda et Habe, 1961

Punctacteon kirai (Habe, 1949)

Acteon kirai Habe, 1949, p. 81, 83, fig. 1; Poppe, 2010, p. 40, pl. 711, figs. 6, 7.

Punctacteon kirai (Habe, 1949): Hori, 2000, p. 733, pl. 365, fig. 6; Hylleberg, Kilburn, 2003, p. 117–118; Thach, 2005, p. 228, pl. 71, fig. 29.

C o m m e n t s. The species was found on sandy mud bottoms at 60–130 m depth (Thach, 2005). There is no a single point of view on the validity of *Punctacteon* (Valdés, 2008). The species is regarded as belonging to *Punctacteon* following Bouchet (2015).

Genus *Pupa* Röding, 1798

Pupa affinis (A. Adams, 1854)

Solidula affinis A. Adams, 1854a, p. 61.

Pupa cinerea (Watson, 1886): Hylleberg, Kilburn, 2003, p. 118.

Pupa alveola (Souverbie, 1863): Hylleberg, Kilburn, 2003, p. 118; Poppe, 2010, p. 34, pl. 708, figs. 4–6.

Pupa affinis (A. Adams, 1855): Poppe, 2010, p. 34, pl. 708, figs. 2, 3.

C o m m e n t s. *Pupa cinerea* and *Pupa alveola* were recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on the collections of the Institute of Oceanography, Nha Trang and the publications of Nguen X. Duc et al. (1997) and Nguen X. Duc (2001). *Buccinulus affinis* A. Adams, 1855 is considered mistakenly

as the original binomen for *P. affinis* (Rosenberg, Bouchet, 2014). *Tornatella cinerea* Watson, 1855 and *Tornatella alveola* Sowerbie, 1863 are the synonyms of *P. affinis* (Rosenberg, Bouchet, 2014).

***Pupa coccinata* (Reeve, 1842)**

Tornatella coccinata Reeve, 1842a, p. 60; 1842b, pl. CCVI, fig. 10.

Solidula affinis var. *coccinata* (Reeve, 1842): Pilsbry, 1893, p. 143, pl. 20A, figs. 40, 41.

Pupa coccinata (Reeve, 1842): Hylleberg, Kilburn, 2003, p. 118; Rudman, 1998 (December 18), fig; Rosenberg, 2015.

Pupa affinis (A. Adams in H. et A. Adams, 1853): Hori, 2000, p. 735, pl. 366, fig. 19 (not A. Adams).

Pupa solidula (L., 1758): Thach, 2005, p. 228, pl. 71, figs. 18, 19 (not Linnaeus, 1758).

C o m m e n t s. The species was found on sand bottoms at 1–25 m depth (Thach, 2005, as *Pupa solidula*). *Pupa coccinata* is “sprinkled with scarlet dots” (Pilsbry, 1893). The species figured as *Pupa affinis* by Hori (2000) has scarlet dots and is actually *P. coccinata*. The specimens figured by Thach (Thach, 2005, pl. 71, figs. 18, 19) look like *Pupa solidula*, but the color on the figure is not easily recognizable and described as follows (l.c., p. 228): “Color white with small and widely spaced red dots on the spiral ribs”. Consequently, it is *P. coccinata*, too. *P. coccinata* was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on the publication of Nguyen X. Duc (2001).

****Pupa sekii* Habe, 1958**

Pupa (Strigopupa) strigosa sekii Habe, 1958, p. 117.

Pupa strigosa strigosa (Gould, 1859): Thach, 2007, p. 159, figs. 825, 848 (non *Buccinulus strigosus* Gould, 1859, nec *Pupa (Strigopupa) strigosa strigosa* sensu Min, 2004).

Pupa sekii Habe, 1958: Poppe, 2010, p. 36, pl. 709, figs. 3, 4.

C o m m e n t s. First record for Vietnam. The species was found on sand bottoms at 1–50 m depth (Thach, 2007, as *Pupa strigosa strigosa*). The specimens figured by Thach (l.c.) as *P. strigosa strigosa* have thick double columellar folds similar to the other species of *Pupa*, and their color is pure white without dark spots. That white form of *P. strigosa* was described as a subspecies by Habe (1958), recorded in Japan from 400 m depth (Higo, Goto, 1993) and in the Philippines from 50–150 m. The Korean *P. (Strigopupa) strigosa strigosa* sensu Min (2004) has a simple columellar fold and belongs to the genus *Japonactaeon* Taki, 1954.

***Pupa solidula* (L., 1758)**

Bulla solidula Linnaeus, 1758, p. 728.

Pupa solidula (L., 1758): Hylleberg, Kilburn, 2003, p. 118; Poppe, 2010, p. 36, pl. 709, figs. 5–7.

Comments. The species was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on the voucher material from the Institute of Oceanology (Hai Phong), Research Institute for Aquaculture No. 3 (Nha Trang), Institute of Oceanography (Nha Trang) and specimens identified by R.N. Kilburn and D.G. Reid.

***Pupa sulcata* (Gmelin, 1791)**

Voluta sulcata Gmelin, 1791, p. 3436.

Pupa sulcata (Gmelin, 1791): Hylleberg, Kilburn, 2003, 118; Thach, 2005: 228, pl. 71, figs. 17, 20; Poppe, 2010, p. 38, pl. 710, figs. 6–8.

Comments. The species was found on sand bottoms at 1–25 m depth (Thach, 2005). The species was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on the collections of the Institute of Oceanography, Nha Trang.

Family **Bullinidae** Gray, 1850

Genus ***Bullina*** Férussac, 1822

***Bullina nobilis* Habe, 1950**

Bullina nobilis Habe, 1950, p. 19, pl. 3, fig. 11.

Bullina nobilis Habe, 1950: Thach, 2005, 228, pl. 8, fig. 25; Poppe, 2010, p. 48, pl. 715, figs. 1–4.

Comments. The species was found on sand bottoms at 20–40 m depth (Thach, 2005). *B. nobilis* is characterized by spiral and longitudinal red strips and differs from *B. bruguiei* A. Adams, 1850 in having a more globose form (Habe, 1950). A color variation of *B. nobilis* is presented by Poppe (2010), who figured specimens with frequent and rare longitudinal strips, and one specimen even almost without that strips (living specimen on p. 48). The latter suggests the synonymy of *B. nobilis* and *Bullina callizona* Sakurai et Habe in Habe, 1961.

Family **Aplustridae** Gray, 1847 (=Hydatinidae Pilsbry, 1895)

Genus ***Hydatina*** Schumacher, 1817

***Hydatina albocincta* (Van der Hoeven, 1839)**

Bulla albocincta Van der Hoeven, 1839, p. 25–27, pl. 10, figs. 2, 3 (cited after Bijl, Vorskui, 1993).

Hydatina albocincta (van der Hoeven, 1839): Hylleberg, Kilburn, 2003, p. 118; Thach, 2005, p. 229, pl. 71, figs. 2, 3; Poppe, 2010, p. 46, pl. 714, figs. 5–7.

Comments. The species was found on sand bottoms at 10–80 m depth (Thach, 2005). The species was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on the voucher material from the Institute of Oceanography, Nha Trang, and identified by D.G. Reid.

Hydatina physis (L., 1758)

Bulla physis Linnaeus, 1758, p. 727.

Hydatina physis (L., 1758): Dawydoff, 1952, p. 108; Hylleberg, Kilburn, 2003, p. 118; Thach, 2005, p. 229, pl. 71, figs. 1, 4; Poppe, 2010, p. 46, pl. 714, figs. 2, 3.

C o m m e n t s. The species was found on sand bottoms at 5–20 m depth (Thach, 2005).

Hydatina zonata (Lightfoot, 1786)

Bulla zonata Lightfoot, 1786, p. 159.

Hydatina zonata (Lightfoot, 1786): Rudman, 2001; Hylleberg, Kilburn, 2003, p. 118; Thach, 2005, p. 229, pl. 61, figs. 6, 8; Poppe, 2010, p. 46, pl. 714, fig. 1.

C o m m e n t s. The species was found on sand bottoms at 10–40 m depth (Thach, 2005). The species was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on a specimen collected by K.R. Jensen.

Genus *Aplustrum* Schumacher, 1817

Aplustrum amplustre (L., 1758)

Bulla amplustre Linnaeus, 1758, p. 727.

Bulla aplustra L., 1758: Dawydoff, 1952, p. 108.

Hydatina amplustre (L., 1758): Hylleberg, Kilburn, 2003, p. 118; Thach, 2005, p. 229, pl. 71, figs. 28, 30.

Aplustrum amplustre (L., 1758): Poppe, 2010, p. 44, pl. 713, figs. 3–5.

C o m m e n t s. The species was found on sand bottoms at 20–60 m depth (Thach, 2005). The species was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on data of Dawydoff (1952).

Superfamily **Ringiculoidea** Philippi, 1853

Family **Ringiculidae** Philippi, 1853

Genus **Ringicula** Deshayes, 1838

Ringicula doliaris Gould, 1860

Ringicula doliaris Gould, 1860, p. 325; Hylleberg, Kilburn, 2003, p. 118; Poppe, 2010, p. 100, pl. 741, figs. 4, 5.

C o m m e n t s. The species was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on the collections of the Institute of Oceanography, Nha Trang, and the publications of Nguen X. Duc et al. (1997) and Nguen X. Duc (2001).

**Ringicula kurodai* Takeyama, 1935

Fig. 1A

Ringicula (Ringiculella) pacifica kurodai Takeyama, 1935, p. 79–80, pl. 6, figs. 26–29.

Ringiculina kurodai (Takeyama, 1935): Hori, 2000, p. 739, pl. 368, fig. 3.

Material. 07.05.2009, Vietnam, Rock Nok, 16–22 m, coll. B. Sirenko (1 shell).

Description. Shell height 1.8 mm; species differs from other members of *Ringicula* in having elongated shell and less swollen body whorl. Spire consists of 4 whorls, ornamented with regular spiral striae; protoconch of 1.5 whorls; aperture wide, margins joined by thickened, slightly expanded callus; parietal callus with one fold, columellar margin with two folds, outer lip thickened in the middle, subdentate.

Comments. First record for Vietnam. The species was found at 16–22 m depth. The species resembles *Ringicula noumeensis* Morlet, 1880 from New Caledonia, but the latter has narrower body whorl and aperture (Pilsbry, 1893, pl. 43, figs. 20, 21; Valdés, Héros, 1998).

Informal Group **OPISTHOBRANCHIA**

Order **CEPHALASPIDEA**

Superfamily **Bulloidea** Gray, 1827

Family **Bullidae** Gray, 1827

Genus *Bulla* Linnaeus, 1758

Bulla ampulla L., 1758

Fig. 2A

Bulla ampulla Linnaeus, 1758, p. 1183; Dawydoff, 1952, p. 108; Hylleberg, Kilburn, 2003, p. 120; Thach, 2005, 230 pl. 71, figs. 7, 12; Malaquias, Reid, 2008, p. 500–517, figs. 25A, 26A–J, 28A, B, 29A, B, 30A–C, 31A–C, 32A, B, 33A–D, 35A–H, 37A–C, 38 (synonymy, re-description); Poppe, 2010, p. 102, pl. 742, figs. 2–4.

Material. 02.04.2010, Nha Trang Bay, Che Isl., 12 m, muddy sand, coll. B. Sirenko (1 shell).

Comments. The species was found among seaweeds at 1–12 m depth (Thach, 2005; this study). It was originally recorded for the Gulf of Siam (=Gulf of Thailand) by Morlet (1889).

Bulla vernicosa Gould, 1859

Bulla vernicosa Gould, 1859, p. 138; Willan, 1978, p. 63–66, figs. 3–14; Hylleberg, Kilburn, 2003, p. 120; Thach, 2005, p. 230, pl. 71, fig. 6; Malaquias, Reid, 2008, p. 527–530, figs. 25D, F, 27L–Q, 28G, H, 29F, 30G, H, 31G, H, 32F, 34C, D, 36F–H, 37J, K, 39 (synonymy, re-description); Poppe, 2010, p. 102, pl. 742, figs. 5, 6.

Bulla difficilis Habe, 1950: Thach, 2005, p. 230, pl. 71, fig. 13 (syn. Malaquias, Reid (2008)).

Bulla punctulata: Thach, 2005, 230, pl. 71, fig. 8 (non A. Adams, 1850 (see Malaquias, Reid, 2008)).

C o m m e n t s. The species was found near rocks at 1–25 m depth (Thach, 2005, this study).

Family **Retusidae** Thiele, 1925

Genus ***Retusa*** T. Brown, 1827

****Retusa concentrica*** (A. Adams, 1850)

Fig. 3D, H, I

Bulla (*Cylichna*) *concentrica* A. Adams, 1850, p. 594, pl. 125, fig. 146.

Retusa (*Coleophysis*) *concentrica* (A. Adams, 1855): Hori, 2000, p. 748, pl. 372, fig. 14.

M a t e r i a l. 07.05.2009, Vietnam, Rock Nok, 16–22 m, coll. B. Sirenko (35 shells); 13.05.2009, Mun Isl., 6–7 m, coll. B. Sirenko (11 shells).

C o m m e n t s. First record for Vietnam. The species was collected from 6–22 m depth.

****Retusa waughiana*** Hedley, 1899

Fig. 3E–G

Retusa waughiana Hedley, 1899, p. 482; Valdés, 2008, p. 732–733, figs. 71G, H, 74.

Retusa (*Coleophysis*) *waughiana* Hedley, 1899: Hori, 2000, p. 748, pl. 372, fig. 14.

M a t e r i a l. 07.05.2009, Vietnam, Rock Nok, 16–22 m, coll. B. Sirenko (8 shells); 13.05.2009, Mun Isl., 6–7 m, coll. B. Sirenko (3 shells).

C o m m e n t s. First record for Vietnam. The species was collected from 6–22 m depth.

Family **Acteocinidae** Dall, 1913

Genus ***Acteocina*** Gray, 1847

Acteocina decorata (Pilsbry, 1904)

Tornatina decorata Pilsbry, 1904, 37, pl. 5, fig. 51.

Acteocina decorata (Pilsby, 1904): Hori, 2000, p. 745, pl. 371, fig. 33; Hylleberg, Kilburn, 2003, p. 118; Bouchet, 2015.

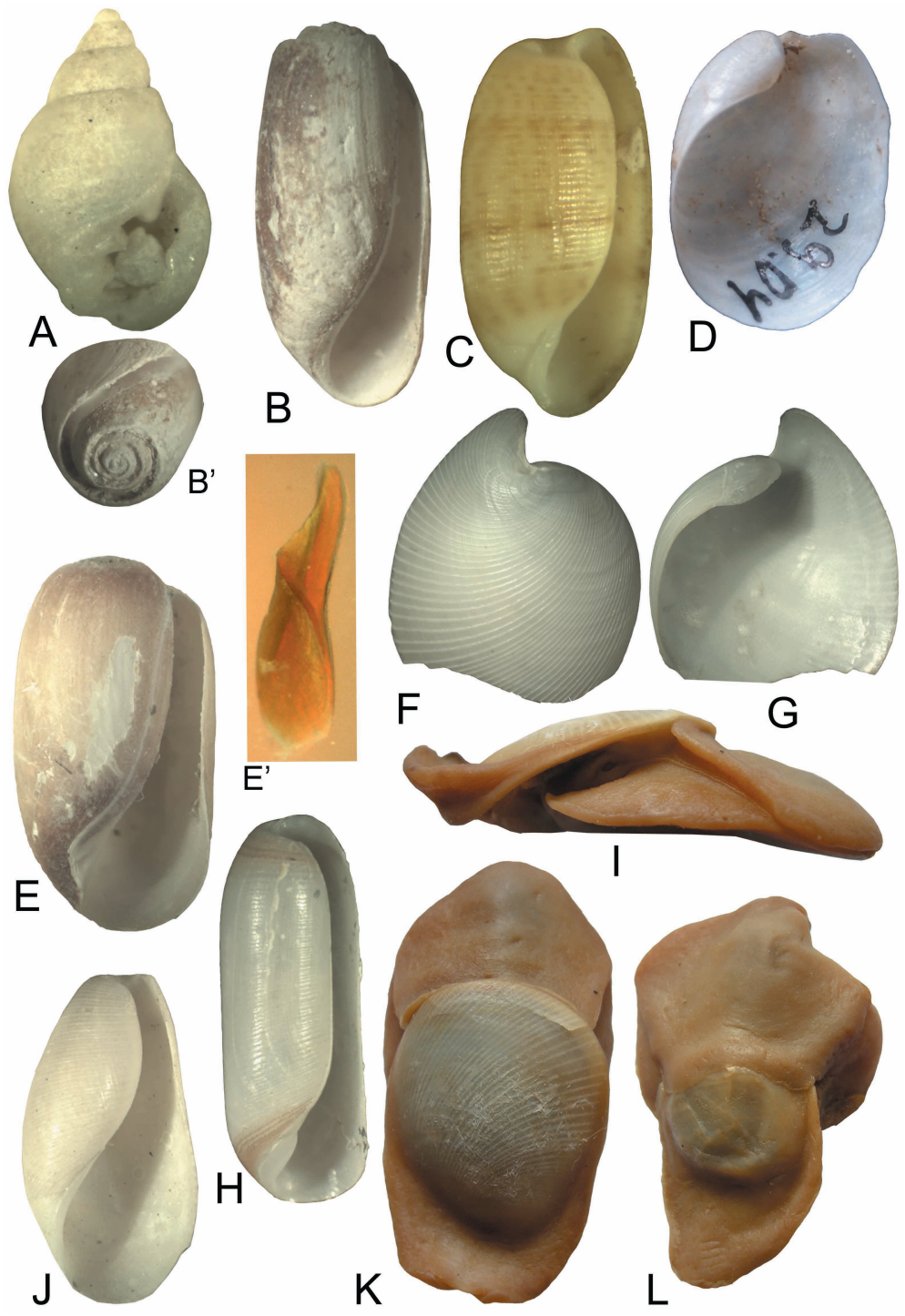
C o m m e n t s. The species is considered as occurring in Vietnam by Hylleberg and Kilburn (2003) based on the collections of the Institute of Oceanology, Hai Phong and on the publications of Nguyen Duc et al. (1997) and Nguyen Duc (2001).

Superfamily **Haminoeidea** Pilsbry, 1895

Family **Haminoeidae** Pilsbry, 1895

Genus ***Haminoea*** Leach in Gray, 1847

(=*Haloa* Pilsbry, 1921 – syn. Rudman, 1971)



***Haminoea binotata* Pilsbry, 1895**

Haminoea binotata Pilsbry, 1895, p. 185.

Haloa binotata (Pilsbry, 1895): Habe, 1952, p. 148–149, pl. 21, fig. 30; Hori, 2000, p. 755, pl. 375, fig. 1; Thach, 2007, p. 159, fig. 820.

C o m m e n t s. The species was found among seaweeds at 1–5 m depth (Thach, 2007).

***Haminoea crocata* Pease, 1860**

Haminoea crocata Pease, 1860, p. 19.

Haminea crocata Peak: Dawydoff, 1952, p. 108.

Haminoea crocata Pease, 1860: Rudman, 1971, p. 554, fig. 10A (reproductive system); Hylleberg, Kilburn, 2003, p. 120.

C o m m e n t s. The species was recorded by Serène (1937), Dawydoff (1952) and later by Hylleberg and Kilburn (2003) as occurring in Vietnam, based on specimens collected from Poulo Condore and stored in the Institute of Oceanography, Nha Trang.

***Haminoea cymbalum* (Quoy et Gaimard, 1833)**

Bulla cymbalum Quoy et Gaimard, 1833, p. 362, pl. 26, figs. 26, 27.

Haminoea cymbalum (Quoy et Gaimard, 1835): Rudman, 1971, p. 553, fig. 9 (reproductive system); Hori, 2000, p. 755, pl. 375, fig. 9.

Lamprohaminoea cymbalum (Quoy et Gaimard, 1835): Habe, 1952, p. 151, pl. 20, fig. 15; Thach, 2007, p. 160.

Haminoea simillima Pease, 1868: Rudman, 1971, p. 545.

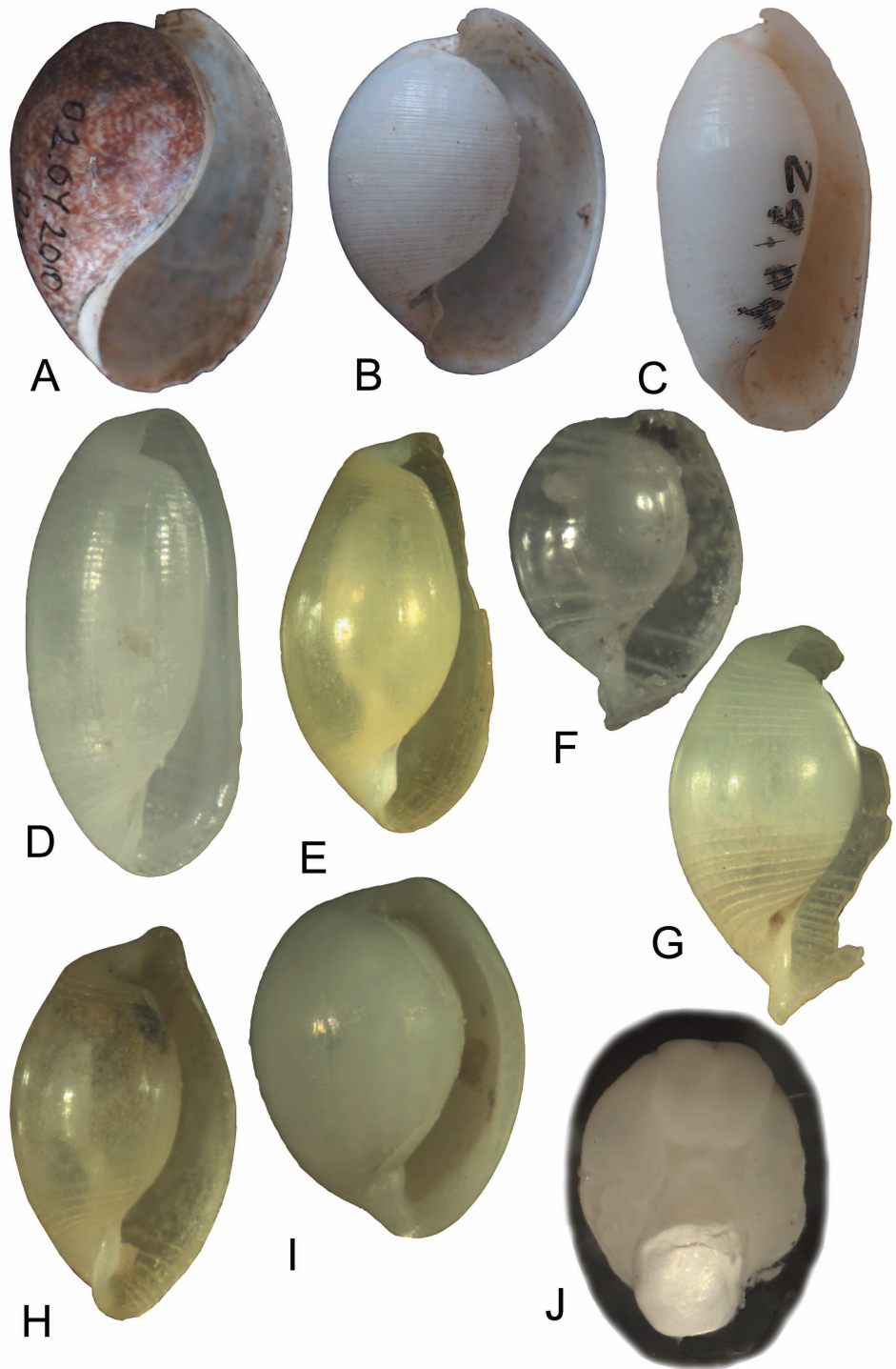
C o m m e n t s. The species was found among algae at 1–5 m depth (Thach, 2007). The species was not illustrated by Thach (l.c.), but described as “body whorl spherical and more swollen than any member of the family”. The species is brilliantly colored (Carlson, Hoff, 1999).

***Haminoea margaritoides* (Kuroda et Habe in Kuroda, Habe et Oyama, 1971)**

Haloa margaritoides Kuroda et Habe in Kuroda, Habe et Oyama, 1971, p. 461, pl. 64, fig. 28; Hori, 2000, p. 755, pl. 375, fig. 3; Thach, 2007, p. 160, fig. 824.

C o m m e n t s. The species was found among seaweeds at 1–5 m depth (Thach, 2007).

Fig. 1. **A** – *Ringiculina kurodai*, h=1.8 mm; **B, B'** – *Tornatina koyasensis*, h=5.0 mm; **C** – *Adamnestia bizona*, h=2.8 mm; **D** – *Philine otukai*, shell, h=19 mm; **F, G, I, K** – *Philinorbis teramachii*, l=28 mm; **H** – *Cyllichna biplicata*, h=5.7 mm; **E, E'** – *Semiretusa borneensis*, h=8.0 mm; **J** – *Scaphander japonicus*, h=12 mm; **L** – *Pseudophilina hayasii*, l=36 mm.



Haminoea ovalis Pease, 1868

Haminoea ovalis Pease, 1868, p. 71, pl. 7, fig. 2, pl. 12, fig. 20.

Haloa ovalis (Pease, 1868): Hylleberg, Kilburn, 2003, p. 119.

Haminoea ovalis Pease, 1868: Valdés, Camacho-García, 2004, p. 481–484, figs. 7A, 8A–C, 9.

C o m m e n t s. The species was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on the voucher material from the Institute of Oceanology, Hai Phong, and the publications of Nguen X. Duc et al. (1997) and Nguen X. Duc (2001). The photo and description of a living colored specimen from the Eastern Pacific are presented by Valdés and Camacho-García (2004).

Haminoea perrieri Morlet, 1889

Haminoea perrieri Morlet, 1889, p. 178, pl. 6, fig. 7; Dawydoff, 1952, p. 108; Hylleberg, Kilburn, 2003, p. 120.

C o m m e n t s. The species was reported by Morlet (1889) from the Gulf of Siam (=Gulf of Thailand). Morlet (l.c.) compared the species with *Haminoea cymbalum* (Quoy et Gaimard, 1833): “Cette espèce, voisine du *Bulla cymbalum*, Quoy et Gaimard, de la Nouvelle-Calédonie, s’en distingue par sa forme un peu plus ovale, par son test un peu plus épais, par son ouverture un peu plus élargie à la base, par les stries spirales qui recouvrent toute la coquille, tandis que le *B. cymbalum* est lisse” (Morlet, 1889). The species was recorded by Dawydoff (1952) and Hylleberg and Kilburn (2003) as occurring in Vietnam based on the publication of Serène (1937).

Haminoea vitrea (A. Adams, 1850)

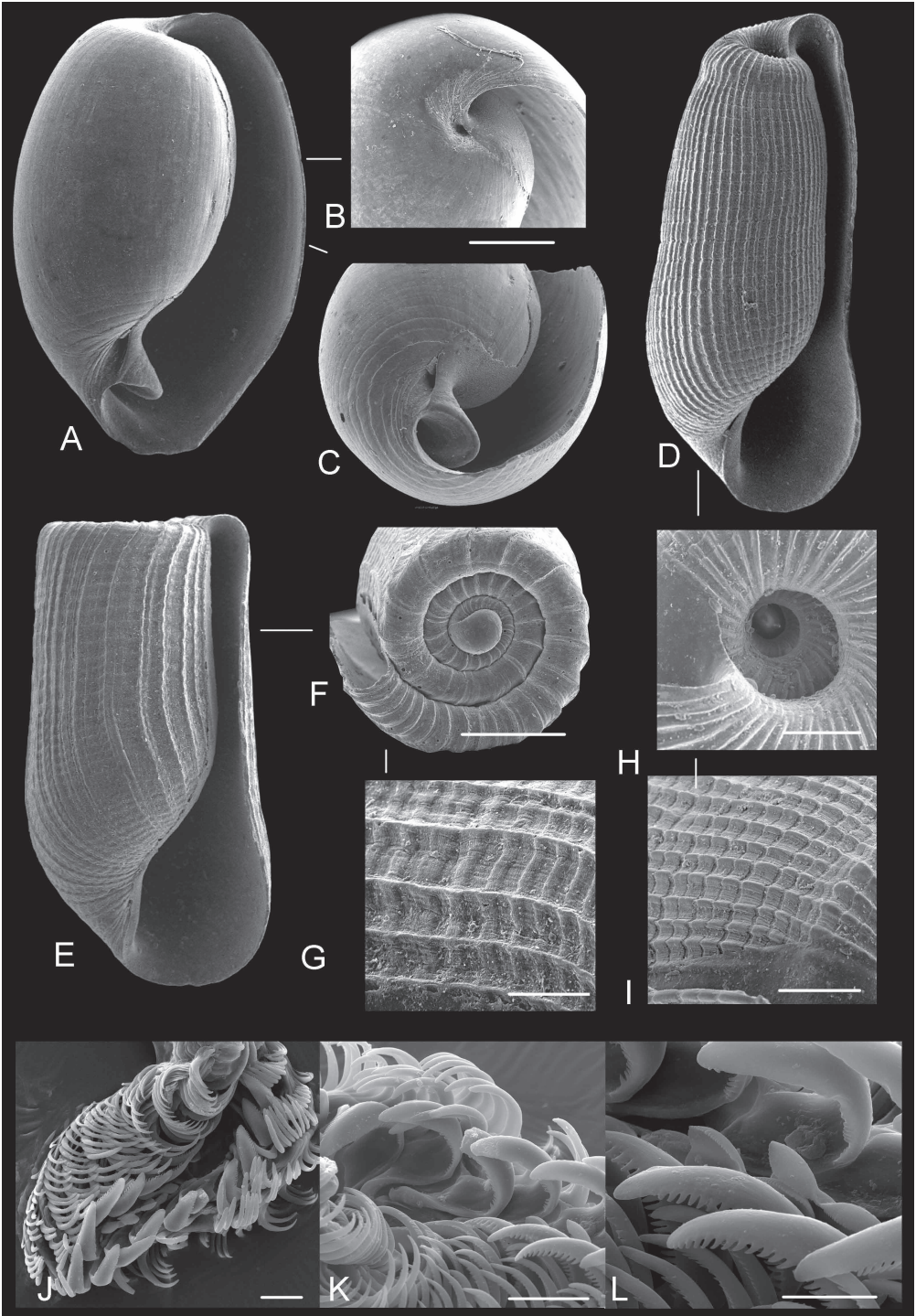
Bulla vitrea A. Adams, 1850, p. 583, pl. 124, fig. 102.

Haloa (Vitreoaminoea) vitrea (A. Adams, 1850): Habe, 1952, p. 150, pl. 20, fig. 8, pl. 21, fig. 28 (radula); Thach, 2007, p. 160, fig. 821.

Haloa cf. *vitrea* (A. Adams, 1850): Hylleberg, Kilburn, 2003, p. 119.

C o m m e n t s. The species was found among seaweeds at 1–5 m depth (Thach, 2007). The specimens regarded by Hylleberg and Kilburn (2003) as *Haloa* cf. *vitrea* were identified by K.R. Jensen. The specimens figured in the books by Thach (2007) and Hori (2000, pl. 375, fig. 6) look oval rather than “ovately cylindrical” (A. Adams, p. 583).

Fig. 2. **A** – *Bulla ampulla*, h=52 mm; **B** – *Atys naucum*, h=45mm; **C** – *Aliculastrum cylindricum*, h=22 mm; **D** – *Liloea curta*, h=2.9 mm; **E** – *Limulatys muscarius*, h=3.1 mm; **F** – *Micratys ovum*, h=1.5 mm; **G** – *Limulatys ooformis*, h=3.0 mm; **H** – *Atys semistriatus*, h=2.0 mm; **I** – *Micratys* cf. *wareni*, h=1.9 mm; **J** – *Phanerophthalmus smaragdinus*, l=2 mm.



Haminoea yamagutii (Habe, 1952)

Haloa (*Sericohaminoea*) *yamagutii* Habe, 1952, p. 150, pl. 20, fig. 16; Thach, 2007, p. 160, fig. 826.

Haloa yamagutii Habe, 1952: Hori, 2000, p. 755, pl. 375, fig. 7.

C o m m e n t s. The species was found among seaweeds at 1–5 m depth (Thach, 2007). Habe (1952) describes the species as having a yellow cylindrical-ovate shell, spiral sculpture visible to the naked eye and a thickened columellar margin.

Genus *Aliculastrum* Pilsbry, 1896

Aliculastrum cylindricum (Helbling, 1779)

Fig. 2C

Bulla cylindrica Helbling, 1779, p. 122, pl. 2, figs. 30, 31.

Atys solida “Brug.”: Dawydoff, 1952, p. 108.

Atys cylindricum (Helbling, 1779): Hylleberg, Kilburn, 2003, p. 119; Thach, 2005, p. 230–231, pl. 71, figs. 16, 21.

Aliculastrum cylindricum Helbling, 1779: Poppe, 2010, p. 106, figures of living specimens, pl. 744, figs. 1, 2; Too et al., 2014, p. 357–362, figs. 1A, 2A, B, 4A–I (synonymy, re-description).

M a t e r i a l. 29.04.2009, Vietnam, Che Isl., under floats, 3–9 m, sand, coll. B. Sirenko (1 shell).

C o m m e n t s. The species was found on sand bottoms at 3–25 m depth (Thach, 2005; present study). It was first recorded for Gulf de Siam (=the Gulf of Thailand) by Morlet (1889) as *Atys elongata* Adams, 1850 and then for Poulo Condore by Dawydoff (1952) as *Atys solida* Dillwyn, 1817 (see Too et al., 2014 for synonymy). Too et al. (2014) noted shell variability of this species. The specimen on Fig. 2C has a slightly angulated shell. This form of the shell was determined earlier as *A. solida* (Dawydoff, 1952). The species has an elongated shell with spiral sculpture on both ends only.

Genus *Atys* Montfort, 1810

Atys hyalinus Watson, 1883

Atys hyalina Watson, 1883, p. 341; 1886, p. 640, pl. 48, fig. 1; Hylleberg, Kilburn, 2003, p. 119.

C o m m e n t s. The species is recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on the voucher material from the Institute of Oceanography, Nha Trang. Hedley (1901) considered that *A. hyalina* was described based upon an immature specimen of *Atys darnleyensis* Brazier, 1877 from Darnley Island, Australia.

Fig. 3. A–C – *Diniatys dentifer*, h=2.2 mm; D, H, I – *Retusa concentrica*, h=2.5 mm; E–G – *Retusa waughiana*, h=2.0 mm; J–L – *Semiretusa borneensis*, radula. Scale bar: B – 0.3 mm, F – 160 µm, G, H, I – 120 µm, G, K – 50 µm, L – 30 µm.

Atys multistriatus Schepman, 1913

Atys multistriata Schepman, 1913, p. 468, pl. 32, fig. 2; Hylleberg, Kilburn, 2003, p. 119; Too et al., 2014, p. 368–370, figs. 1D, 2E, 9A–F (synonymy, re-description).

C o m m e n t s. The species was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on the voucher material from the Institute of Oceanography, Nha Trang. This species is easily distinguished from other species by its reticulate shell sculpture (see Too et al., 2014, fig. 2E).

Atys naucum (L., 1758)

Fig. 2B

Bulla naucum Linnaeus, 1758, p. 726.

Atys naucum (L., 1758): Habe, 1952, p. 137–138, pl. 21, figs. 17, 18; Dawydoff, 1952, p. 108; Hori, 2000, p. 757, pl. 376, fig. 12; Hylleberg, Kilburn, 2003, p. 119; Thach, 2005, p. 231, pl. 71, figs. 5, 9.

M a t e r i a l. 29.04.2006, Vietnam, Che Isl., under floats, coll. B. Sirenko (1 shell); 24.04.2010, Be River, estuary, intertidal, muddy sand, coll. B. Sirenko (1 shell). 07.05.2009, Vietnam, Rock Nok, 16–22 m, coll. B. Sirenko, h 1.9 mm, d 1.4 mm.

C o m m e n t s. The species was found on muddy sand bottoms from the intertidal to 22 m (Thach, 2005; present study). It was first recorded for Gulf of Siam (=the Gulf of Thailand) by Morlet (1889).

**Atys semistriatus* Pease, 1860

Fig. 2H

Atys semistriata Pease, 1860, p. 20.

Atys (Alicula) semistriata Pease, 1860: Pilsbry 1893, p. 267, pl. 28, fig. 30.

Atys semistriatus Pease, 1860: Too et al., 2014, p. 372–374, figs. 2G, 11 A–F, 12 (paratype).

M a t e r i a l. 07.05.2009, Rock Nok, 16–22 m, coll. B. Sirenko (1 shell).

D e s c r i p t i o n. Shell height 2.0 mm, shell translucent, apex perforated; spiral groove on the ends of the shell; umbilicus opened, columella slightly twisted, anterior end of the aperture protruded.

C o m m e n t s. First record for Vietnam. An empty shell was collected at 16–22 m depth. Species resembles *Limulatus ooformis* Habe, 1952 (Hori, 2000, p. 757, fig. 14), but has translucent shell; it differs from *A. semistriata* figured by Pilsbry (1893, p. 267, pl. 28, fig. 30) in having a wider posterior end of the shell. Habe (1952) noted that *L. ooformis* resembles *A. semistriata* and has been erroneously identified by some authors as this species, but may be distinguished from the latter in having a more elongate shell. The complete description, including that of internal morphology and a photo of the type specimen, is given in Too et al. (2014).

Genus *Limulatys* Iredale, 1936

**Limulatys muscarius* (Gould, 1859)

Fig. 2E

Atys muscaria Gould, 1859, p. 139.

Haminea angustata Gould, 1859, p. 139 – syn. Higo, Goto, 1993.

Limulatys muscarius (Gould, 1859): Habe, 1952, p. 140, pl. 20, fig. 1; Hori, 2000, p. 757, pl. 376, fig. 15; Poppe, 2010, p. 108, pl. 745, fig. 5.

Limulatys angustatus (Gould, 1859): Habe, 1952, p. 140, pl. 21, fig. 21.

Material. 13.05.2009, Vietnam, Mun Isl., 6–7 m, coll. B. Sirenko (1 shell).

Description. Shell 3.1 mm in height, transparent, covered with spiral grooves on both ends; umbilicus opened, columella slightly twisted. Shell yellowish, columella white.

Comments. First record for Vietnam. The species was found at 6–7 m depth. The color of the shell is noted as greenish by Gould (1859), as greenish-yellow by Hori (2000) and as yellow by Poppe (Poppe, 2010, pl. 745, fig. 5).

**Limulatys ooformis* Habe, 1952

Fig. 2G

Limulatys ooformis Habe, 1952, p. 138–139, pl. 20, fig. 9; Hori, 2000, p. 757, pl. 376, fig. 14.

Material. 13.05.2009, Vietnam, Mun Isl., 6–7 m, coll. B. Sirenko (1 shell); 07.05.2009, Rock Nok, 16–22 m, coll. B. Sirenko (2 shells).

Description. Shell up to 3.0 mm with 10–11 spiral grooves on both ends, columellar margin with a weak fold and an opened umbilicus.

Comments. First record for Vietnam. The species was found at 6–22 m of depth. This species looks like *A. hyalina* (Pilsbry, 1893, pl. 32, fig. 36), but has a wider middle zone without spiral striations, posterior part of shell wide, and upper lip less curved. The shell collected at 6–7 m depth is transparent, but the shells collected at 16–22 m depth are semitransparent.

Genus *Nipponatys* Habe, 1952

Nipponatys volvulinus (A. Adams, 1861)

Alicula volvulina A. Adams, 1861, p. 159.

Atys (Alicula) volvulina (A. Adams): Pilsbry, 1893, p. 270.

Nipponatys volvulinus (A. Adams, 1861): Habe, 1952, p. 141, pl. 20, fig. 5; pl. 21, fig. 27 (radula); Hori, 2000, p. 757, pl. 376, fig. 18; Thach, 2005, p. 231, pl. 8, fig. 29.

Comments. The species was found on sandy mud bottoms at 15–40 m depth (Thach, 2005).

Genus *Liloa* Pilsbry, 1921

Liloa curta (A. Adams, 1850)

Fig. 2D

Bulla curta Adams, 1850, p. 582, pl. 124, fig. 100.

Liloa curta (A. Adams, 1850): Habe, 1952, p. 151, pl. 21, fig. 19; Hori, 2000, p. 757, pl. 375, fig. 11; Hylleberg, Kilburn, 2003, p. 120; Too et al., 2014, p. 383–385, figs. 1J, 3D, 17 A–I (synonymy, re-description).

M a t e r i a l. 07.05.2009, Vietnam, Rock Nok, 16–22 m, coll. B. Sirenko (1 shell).

D e s c r i p t i o n. Shell 2.9 mm high, translucent, elongated, ovate cylindrical; apex with shallow concavity, not umbilicated; columella without fold. Whole shell surface covered with spiral grooves.

C o m m e n t s. The species was found at 16–22 m depth. The species was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on the voucher material from the University of Fisheries, Nha Trang, and the Crude Oil Safety Center, Ho Chi Min City.

Genus *Bullacta* Bergh, 1901

Bullacta exarata (Philippi, 1849)

Bullaea exarata Philippi, 1849, p. 141.

Bullacta exarata (Philippi, 1848): Hylleberg, Kilburn, 2003, p. 120; Malaquias, 2010, p. 2017–2021, figs. 1–6 (re-description, synonymy).

C o m m e n t s. The family Bullactidae Thiele, 1926 was created for *Bullacta exarata* due to morphological features of the species, but the family was not supported by Malaquias (2010). The occurrence of the species in estuarine habitats was registered by Malaquias (l.c.). The species was recorded by Hylleberg and Kilburn (2003) as living in Vietnam based on the publications of Nguen X. Duc et al. (1997) and Nguen X. Duc (2001).

Genus *Diniatys* Iredale, 1936

**Diniatys dentifer* (A. Adams, 1850)

Fig. 3A–C

Bulla dentifera Adams, 1850, p. 588, pl. 115, fig. 124.

Diniatys dentifer Adams, 1850: Habe, 1952, p. 141–142, pl. 20, fig. 12; Burn, 1978, p. 109, figs. 19–25; Hori, 2000, p. 757, pl. 376, fig. 19; Too et al., 2014, p. 378, figs. 1H, 3B, 14A–F, 15A–C.

M a t e r i a l. 02.05.2009, Vietnam, Rock Nok, 15 m, coll. B. Sirenko (6 shells); 07.05.2009, Rock Nok, 16–22 m, coll. B. Sirenko (3 shells); 13.05.2009, Vietnam, Mun Isl., 6–7 m, coll. B. Sirenko (8 shells); 23.05.2015, Rock Nok, 15–20 m, coll. B. Sirenko (1 shell).

Description. Shell oval; apex perforated; umbilicus opened; weak spiral groove present on anterior end of shell. The presence of a strong horizontal fold on the columella and an ovoid shape of the shell are characteristic features of the species.

Comments. First record for Vietnam. The species was collected at 6–22 m depth. Burn (1978) notes a quite smooth shell. The unperforated apex and the absence of umbilicus were included in the diagnosis of *Diniatys* by Burn (1978). Figure 16C of Too et al. (2014) demonstrates the perforated apex of *Diniatys dubia* (Schepman, 1913); our specimens have the perforated apex too and the opened umbilicus.

Genus *Micratys* Habe, 1952

**Micratys ovum* Habe, 1952

Fig. 2F

Micratys ovum Habe, 1952, p. 143, pl. 20, fig. 3; Hori, 2000, p. 757, pl. 376, fig. 22.

?*Atys palmarum* Hedley, 1912, p. 158, pl. xlv, fig. 41.

Material. 07.05.2009, Rock Nok, 16–22 m, coll. B. Sirenko (1 shell).

Description. Shell minute, transparent, spherical in shape; apex truncated; sculpture consists of three spiral grooves, both at the upper and lower ends; umbilicus opened, columellar margin straightened, without fold.

Comments. First record for Vietnam. Empty shell was collected at 16–22 m depth. The species is very close to the Australian *Atys palmarum* Hedley, 1912.

**Micratys* cf. *wareni* Valdés, 2008

Fig. 2I

Micratys wareni Valdés, 2008, p. 770–772, figs. 93A–C, 94.

Material. 07.05.2009, Vietnam, Rock Nok, 16–22 m, 1 shell, coll. B. Sirenko.

Description. Shell minute, white, solid, spherical in shape, opaque white, height 1.9 mm, width 1.4 mm. Apex not perforated; outer lip rises slightly above apex, regularly rounded in the middle of aperture; columella short, thickened; umbilicus closed but umbilical pit present. Shell surface smooth, shiny, without sculpture, excluding rare equally spaced longitudinal wrinkles, three on ventral side and three on dorsal side, one of them looking like fine ridge. Traces of 3–4 spiral striations partly visible on lower part of shell.

Comments. First record for Vietnam. Empty shell was collected at 16–22 m depth. *M. wareni* has spiral striation on both ends of the shell (Valdés, 2008), whereas our specimen (an empty shell) has traces of spiral striation only on the lower part of the shell.

Genus *Phanerophthalmus* A. Adams, 1850

Phanerophthalmus smaragdinus (Rüppell et Leuckart, 1828)

Fig. 2J

Bulla smaragdina Rüppell, Leuckart 1828, p. 26, pl. 11, fig. 2 A–D.

Cryptophtalmus smaragdinus Leuckart: Dawydoff, 1952, p. 108.

Lathophtalmus smaragdinus (Rüppell et F.S. Leuckart, 1828): Marcus, Burch, 1965, p. 238–239.

Phanerophthalmus smaragdinus (Rüppell et Leuckart, 1828): Rudman 1972b, p. 190–200, pl. 1, figs. 1–4; Hylleberg, Kilburn, 2003, p. 120; Hori, 2000, p. 759, pl. 377, fig. 3 (shell and alive specimen); Martynov, Korshunova, 2012, p. 149, pl. 22, fig. C.

M a t e r i a l. 11.05.2005, Vietnam, R/V *Akademik Oparin*, (2 specimens), collected by A.V. Chernyshev.

C o m m e n t s. The species was found in the intertidal zone, up to 1 m, usually associated with green algae (Martynov, Korshunova, 2012).

Superfamily **Philinoidea** Gray, 1850 (1815)

Family **Philinidae** Gray, 1850 (1815)

Genus *Philine* Ascanius, 1772

Philine kurodai Habe, 1946

Philine kurodai Habe, 1946, p. 187–189, figs. 1, 2; Thach, 2005, p. 229–230, pl. 71, figs. 23, 24.

C o m m e n t s. The species was found on sand bottoms at 50–150 m depth (Thach, 2005). The form of the shell (Thach, 2005, pl. 71, figs. 23, 24) resembles that of *Philine orientalis* A. Adams, 1854, but differs from it in the presence of several spiral grooves on the posterior part of the body whorl, as was noted by Thach (l.c., 2005, p. 230). The presence of these grooves was determined by Habe (1946) and Hori (2000) as a character of the species.

Philine orientalis A. Adams, 1854

Philine orientalis A. Adams, 1854b, p. 94; Hylleberg, Kilburn, 2003, p. 119; Poppe, 2010, p. 112, pl. 747, figs. 5, 6; Martynov, Korshunova, 2012, p. 144–145, pl. 21, fig. B.

Philine quadripartita: Dawydoff, 1952, p. 108 (non Ascanius, 1772).

C o m m e n t s. A living specimen was found at 20–107 m depth (Martynov, Korshunova, 2012).

**Philine otukai* Habe, 1946

Fig. 1D

Philine otukai Habe, 1946, p. 161, text-figs. 22, 23.

M a t e r i a l. 29.04.2009, south Vietnam, Cho Isl., Dan By Bay, under the floats, 3–9 m depth, 1 shell, coll. B. Sirenko

Comments. The name of the species was given by Habe (1946) for the specimens, which were determined by Otuka (1936) as *Philine aperta* (L., 1767). According to the figures of the species reprinted by Okamoto (2001, p. 959, figs. 22, 23), the shell is regularly oval with rare weak spiral grooves.

Family **Philinorbidae** Oskars, Bouchet et Malaquias, 2015

Genus ***Philinorbis*** Habe, 1950

Philinorbis teramachii Habe, 1950

Fig. 1F, G, I, K

Philinorbis teramachii Habe, 1950, p. 50, pl. 9, figs. 3–5; Chaban, 2011, p. 37–39.

Philine hearstorum Gonzales et Gosliner, 2014, p. 360–363, figs. 1C–D, 4–5 – **syn. nov.**

Material. South China Sea, near Vietnam, R/V *Odissey*, 22.09.1984, 11°09' N, 110°02' E, mud, 700 m depth, coll. B. Sirenko (2 specimens); 25.09.1984, 11°01' N, 109°55' E, depth 460 m, mud, coll. B. Sirenko (1 specimen).

Comments. The species was found at 460–700 m depth. The shell (height 15 mm and width 13 mm, Fig. 1F, G) is nearly circular in outline, with a large flattened body whorl, the upper edge has a small triangular process arising under a small spire. The spiral sculpture consists of numerous well-expressed straight grooves.

Genus ***Pseudophiline*** Habe, 1976

Pseudophiline hayashii Habe, 1976

Fig. 1L

Pseudophiline hayashii Habe, 1976b, p. 154, pl. 1, figs. 1, 2; Kitao, Habe, 1982, p. 61, figs. 3–5; Hori, 2000, p. 751, 753, pl. 373, fig. 12.

Philinorbis hayashii (Habe, 1976): Chaban, 2011, p. 37.

Philine acuticauda Gonzales et Gosliner, 2014, p. 355–360, figs. 1A–B, 2–3 – **syn. nov.**

Material. South China Sea near Vietnam, R/V *Odissey*, 25.09.1984, 11°01' N, 109°55' E, depth 460 m, mud, coll. B. Sirenko (1 specimen).

Comments. The species was found at 460 m depth. The shell is with lines of growth but without spiral grooves.

Family **Aglajidae** Pilsbry, 1895 (1847)

Genus ***Philinopsis*** Pease, 1860

Philinopsis lineolata (H. et A. Adams, 1854)

Aglaja lineolata H. et A. Adams, 1854, p. 27, pl. 58, fig. 4.

Doridium lineolatum (H. et A. Adams, 1854): Dawydoff, 1952, p. 108.

Philinopsis lineolata (H. et A. Adams, 1854): Hylleberg, Kilburn, 2003, p. 119.

***Philinopsis cyanea* (Martens, 1879)**

Doridium cyaneum Martens, 1879: 738.

Philinopsis cyanea (Martens, 1879): Rudman, 1972a, p. 381–394, fig. 15; Martynov, Korshunova, 2012, p. 145, pl. 21, fig. E.

C o m m e n t s. The species was found at 12–20 m depth (Martynov, Korshunova, 2012).

***Philinopsis gardineri* (Eliot, 1903)**

Doridium gardineri Eliot, 1903, p. 332–333.

Philinopsis gardineri (Eliot, 1903): Rudman 1972a, p. 381–396, fig. 9; Martynov, Korshunova, 2012, p. 146–147, pl. 21, fig. F.

***Philinopsis pilsbryi* (Eliot, 1899)**

Doridium (Aglaia) pilsbryi Eliot, 1899, p. 512–513, pl. 19, figs. 1a, b.

Philinopsis pilsbryi (Eliot, 1899): Rudman 1972a, p. 381–397, figs. 1, 5, 8, 14K; Martynov, Korshunova, 2012, p. 147, pl. 21, fig. G.

***Philinopsis reticulata* (Eliot, 1903)**

Doridium reticulatum Eliot 1903, p. 335, pl. 13, fig. 1.

Philinopsis reticulata (Eliot, 1903): Martynov, Korshunova, 2012, p. 147–148, pl. 21, fig. H.

C o m m e n t s. The species was found at 10–15 m depth (Martynov, Korshunova, 2012).

Genus *Chelidonura* A. Adams, 1850

***Chelidonura amoena* Bergh, 1905**

Chelidonura amoena Bergh 1905, p. 43, 45–46, Taf. 3, fig. 7; Hylleberg, Kilburn, 2003, p. 119; Martynov, Korshunova, 2012, p. 145, pl. 21, fig. C.

C o m m e n t s. The species was found at a depth of 14 m (Martynov, Korshunova, 2012).

***Chelidonura fulvipunctata* Baba, 1938**

Chelidonura fulvipunctata Baba, 1938, p. 3–4, fig. 1; Martynov, Korshunova, 2012, p. 145–146, pl. 21, fig. D.

C o m m e n t s. The species was found at a depth of 8 m (Martynov, Korshunova, 2012).

Family **Gastropteridae** Swainson, 1840
Genus ***Sagaminopteron*** Tokioka et Baba, 1964

Sagaminopteron ornatum Tokioka et Baba, 1964

Sagaminopteron ornatum Tokioka, Baba 1964, p. 218–224, figs. 9–14, pl. 10, figs. 1–7, pl. 12, figs. 4–8, pl. 13, figs. 5, 6; Martynov, Korshunova, 2012, p. 148, pl. 22, fig. A.

Genus ***Siphopteron*** Gosliner, 1989

Siphopteron nigromarginatum Gosliner, 1989

Siphopteron nigromarginatum Gosliner 1989, p. 345–348, figs. 1C, 12, 13; Martynov, Korshunova, 2012, p. 148–149, pl. 22, fig. B.

C o m m e n t s. The species was found at 5–8 m depth (Martynov, Korshunova, 2012).

Family **Colpodaspididae** Oskars, Bouchet et Malaquias, 2015
Genus ***Colpodaspis*** M. Sars, 1870

Colpodaspis thompsoni G.H. Brown, 1979

Colpodaspis thompsoni G.H. Brown, 1979, p. 217–220, pl. Ia, figs. 7, 8; Martynov, Korshunova, 2012, p. 144, pl. 21A.

C o m m e n t s. The species was found on coral reefs at 3–8 m depth (Martynov, Korshunova, 2012).

Family **Scaphandridae** G.O. Sars, 1878
Genus ***Scaphander*** Montfort, 1810

****Scaphander japonicus*** A. Adams, 1862

Fig. 1J

Scaphander japonicus A. Adams, 1862, p. 156; Valdés, 2008, p. 669–674, figs. 38, 39, 40A, 41; Poppe, 2010, p. 130, pl. 760, figs. 4, 5.

Nipponoscapander japonica (A. Adams, 1862): Hori, 2000, p. 741, pl. 369, fig. 2.

M a t e r i a l. 23–24.07.1961, southern Gulf of Tonkin, coll. E. Gurjanova (1 shell); 24.07.1961, R/V *Pelamida*, 17°37' N, 108°33' E, 86 m, sand, mud, station 12, coll. E. Gurjanova (1 shell); 23.07.1961, R/V *Pelamida*, 17°30' N, 109°37' E, 113 m, clay, mud, station 9, coll. E. Gurjanova (1 shell).

C o m m e n t s. First record for Vietnam. The species was found on sandy or clayey silt bottoms at 86–113 m depth.

Superfamily **Diaphanoidea** Odhner, 1914 (1857)

Family **Cylichnidae** H. et A. Adams, 1854

Subfamily **Cylichninae** s.str.

Genus **Cylichna** Lovén, 1846

Cylichna biplicata (A. Adams, 1850)

Fig. 1H

Bulla biplicata A. Adams, 1850, p. 593, pl. 125, fig. 143.

Eocylichna braunsi (Yokoyama, 1920): Hylleberg, Kilburn, 2003, p. 118; Min, 2004, fig. 936; Poppe, 2010, p. 134, pl. 758, fig. 4.

Cylichna biplicata (A. Adams in Sowerby, 1850): Valdés, 2008, p. 652–656, figs. 30A–C, 31A, B, 32A, 33.

M a t e r i a l. 28.07.1961, R/V *Pelamida*, the Gulf of Tonkin, station 32, 79 m, 18°01' N, 107°34' E, coll. E. Gurjanova (1 shell); 08.01.2005, R/V *Akademik Oparin*, Che, 20 m depth, coll. A.V. Chernyshev (1 spm.).

C o m m e n t s. The species was found at 20–79 m depth. Collected specimens are 2.0–5.7 mm in height. The species has been recorded as occurring in Vietnam first as *Eocylichna braunsi*, but it is a junior synonym of *Cylichna biplicata* (see Valdés, 2008).

Subfamily **Semiretusinae subfam. nov.**

T y p e g e n u s. *Semiretusa* Thiele, 1925.

T y p e s p e c i e s. *Semiretusa borneensis* (A. Adams, 1850).

D i a g n o s i s. Shell ovate-cylindrical, covered with brown periostracum, without spiral sculpture, apex projecting. Radula formula 13:1:1:1:13, bilobed denticulated rachidian teeth, first large curved lateral teeth denticulated on both edges, other laterals small and denticulated on outer edges. Three gizzard plates corneous, oval, with three sharp crests on internal surface, all plates of the same shape and size.

Genus ***Semiretusa*** Thiele, 1925

Semiretusa borneensis (A. Adams, 1850)

Figs. 1E, E', 3 J–L

Utriculus borneensis A. Adams, 1850, p. 572, pl. 120, fig. 23.

Retusa (*Semiretusa*) *borneensis* (A. Adams, 1850): Thiele, 1925, pl. 46, fig. 6.

Retusa borneensis (A. Adams, 1850): Hylleberg, Kilburn, 2003, p. 120–121.

M a t e r i a l. 13.08.1961, the Gulf of Tonkin, Chan-ka, coll. N. Tzvetkova (1 shell).

Description. Shell ovate-cylindrical, white, covered with brown periostracum, longitudinally striated, without spiral sculpture. Apex slightly projecting, consists of four whorls, protoconch not protruding. Head shield of the fixed specimen white, short, with postero-lateral extensions, foot white, short, without parapodia. Other parts of soft body including mantle covered with black epithelium. Radula (Fig. 3J–L) 18x13:1:1:1:13; central tooth bilobate with serrated cutting edge, laterals denticulated on both edges, marginals denticulated on one edge. Three gizzard plates (Fig. 1E') corneous, pellucid, brown, of teardrop shape, with three sharp crests on internal surface, all plates have same shape and size. Cephalic penial complex with folded penial sack, short thick penial retractor and prostate, which consists of anterior thick short part and posterior thin one.

Comments. The species is considered as occurring in Vietnam by Hylleberg and Kilburn (2003, as *Retusa borneensis*) based on the collections of the Institute of Oceanology, Hai Phong and on the publications of Nguyen Duc et al. (1997). An empty shell was collected during Russian-Vietnamese expedition in 1961. *Semi-retusa borneensis* has been originally attributed to Retusidae (Thiele, 1925), but is mentioned by Burn and Thompson (1998) as Cylichnidae. The radula of the specimen from Hainan Isl. is shown in Fig. 3J–L. It is similar to the radula of *Decorifer matusimanus* (Nomura, 1939) (see Chaban, Chernyshev, 2014).

The family Cylichnidae includes species with very different morphology of shell and digestive system. Recently, the families Scaphandridae and Acteocinidae (previously listed as synonyms of Cylichnidae) were reinstated as valid (Malaquias et al., 2009; Oskars et al., 2015). The form and size of their paired gizzard plaits differ considerably from those of the unpaired plaits. *S. borneensis* may be referred neither to Scaphandridae, nor to Acteocinidae, as the morphology of its radula, shell and gizzard plates differs from that in both (see Eilersten et Malaquias, 2013 for *Scaphander* and P.S and P.M. Mikkelsen, 1984 for *Acteocina*). All gizzard plates of *S. borneensis* have the same shape and size as in the *Cylichna* and are similarly enveloped in transverse muscles. However, the gizzard plates of *S. borneensis* are pellucid and with sharp crests, and the laterals are denticulated on both sides, which differs considerably from the smooth gizzard plates and the laterals denticulated on one side in *Cylichna*. These features and the projecting apex of the shell are believed to be relevant for the erection of a new subfamily for *S. borneensis*.

Genus *Decorifer* Iredale, 1937

Decorifer insignis (Pilsbry, 1904)

Tornatina insignis Pilsbry, 1904, p. 36–37, pl. V, figs. 49, 49a.

Acteocina (Decorifer) insignis (Pilsbry, 1904): Oyama, 1992, p. 70.

Retusa (Decorifer) insignis (Pilsbry, 1904): Higo, Goto, 1993, p. 401; Hori, 2000, p. 747, pl. 371, fig. 2.

Acteocina insignis (Pilsbry, 1904): Hylleberg, Kilburn, 2003, p. 118.

Comments. The species is considered as occurring in Vietnam by Hylleberg and Kilburn (2003) based on the collections of the Institute of Oceanology, Hai Phong and on the publications of Nguyen Duc et al. (1997) and Nguyen Duc (2001).

The species is usually considered as belonging to *Decorifer* (see synonymy). Anatomical examination of one species of the genus, *D. matusimanus* shows that the radula morphology is similar to that in *S. borneensis*, the gizzard plates have ridges directed from the center to the ends, and all plates have the same shape and size (Chaban, Chernyshev, 2014). Therefore, *D. insignis* is tentatively maintained within the subfamily Semiretusinae.

Subfamily **Tornatininae** P. Fischer, 1883

Type genus. *Tornatina* A. Adams, 1850.

Type species. *Tornatina gaimardi* Finlay, 1927.

Diagnosis. Shell ovate-cylindrical, with weak spiral striae, apex flat or projecting. Radula 1:1:1. The first large lateral teeth denticulated on both sides. Gizzard plates calcified; two plates large, curved; the third one rounded and very small.

Comments. Anatomy of the type species, *Tornatina gaimardi*, was described by Ev. Marcus (1977).

Genus ***Tornatina*** A. Adams, 1850

(=*Didontoglossa* Annandale, 1924; *Neacteocina* Kuroda et Habe, 1952; *Truncacteocina* Kuroda et Habe, 1954 – syn. Chaban, Martynov, 2001)

****Tornatina koyasensis*** Yokoyama, 1927

Fig. 1B, B'

Tornatina koyasensis Yokoyama, 1927, p. 448, pl. 51, fig. 1.

Didontoglossa koyasensis (Yokoyama, 1927): Hori, 2000, p. 745, pl. 371, fig. 28.

Material. 06.08.1961, the Gulf of Tonkin, Kon-Fi beach (1 shell).

Comments. First record for Vietnam. Assigned in *Didontoglossa* Annandale, 1924 by Hori (2000), but *Didontoglossa* is a junior synonym of *Tornatina* (Chaban, Martynov, 2001).

Family **Mnestiidae** Oskars, Bouchet et Malaquias, 2015

Genus ***Mnestia*** H. et A. Adams, 1854

(=*Ventomnestia* Iredale, 1936 – syn. Oskars, Bouchet and Malaquias, 2015)

Mnestia girardi (Audouin, 1826) – **comb. nov.**

Fig. 1C

Bulla girardi Audouin, 1826, p. 39; Bouchet, Danrigal, 1982, fig. 52 (holotype).

Bulla bizona A. Adams, 1850, p. 595, pl. 125, fig. 148 – syn. Mienis, 1976.

Cylichna (*Mnestia*) *bizona* (A. Adams, 1850): H. et A. Adams, 1854, p. 10; Pilsbry, 1893, 323, pl. 27, fig. 84.

Ventomnestia girardi (Audouin, 1826): Mienis, 1976, p. 209–210, fig. 1; Bouchet, 2015 (WoRMS).

Retusa (*Ventomnestia*) *bizonata* A. Adams, 1850: Hori, 2000, p. 747, pl. 371, fig. 1.

Retusa bizona (A. Adams, 1850): Hylleberg, Kilburn, 2003, p. 120.

Adamnestia bizona (A. Adams, 1850): Poppe, 2010, p. 126, pl. 756, figs. 1–3.

Retusa (*Ventomnestia*) *kawamurai* Kuroda, Habe, 1950: Poppe, 2010, p. 126, pl. 756, figs. 4, 5.

M a t e r i a l. 13.05.2009, Vietnam, Mun Isl., 6–7 m coll. B. Sirenko (2 shells).

C o m m e n t s. The species is known in the West Pacific as *bizona*. It was previously recorded in *Adamnestia* Iredale, 1936, *Mnestia* H. et A. Adams, 1854, *Ventomnestia* Iredale, 1936 or *Retusa* Brown, 1827 (see synonymy), attributing it correspondingly to the families Cylichnidae, Haminoeidae, or Retusidae. *Ventomnestia bizona* is a junior synonym of *V. girardi* from the Red and the Mediterranean seas based on the shell morphology (Mienis, 1976). The genus *Ventomnestia* is a junior synonym of *Mnestia* (see Oskars et al., 2015). Apparently, *Ventomnestia bizona* should be recorded as *Mnestia girardi* (Audouin, 1826) – **comb. nov.**

The species listed below are excluded from the fauna of Vietnam:

Pupa strigosa strigosa (Gould, 1859)

See comments for *Pupa sekii*.

Haminoea virescens (Sowerby, 1833)

Haminoea virescens (Sowerby, 1833): Hylleberg, Kilburn, 2003, p. 120.

C o m m e n t s. The species was recorded by Hylleberg and Kilburn (2003) as occurring in Vietnam based on the voucher material from the University of Natural Science, Ho Chi Minh City. The University has collections for education purposes only with a species name on the label, but without locality (Hylleberg, Kilburn, 2003). The species is distributed mostly in the Eastern Pacific, west coast of North America, from Alaska to Panama (Rudman, 2005) and its presence in Vietnam needs confirmation.

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Marine plant fouling of submerged surfaces of lobster farms in Nha Trang Bay (Vietnam)

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Abstract: The species composition and structure of algal fouling communities on the underwater artificial substrates of lobster farms and benthic marine plants near the farms in Nha Trang Bay (Vietnam, South China Sea) were studied. A total of 133 species of macroalgae and cyanobacteria were collected at the farms, including 22% of Chlorophyta, 18% of Ochrophyta, 54% of Rhodophyta and 6% of Cyanobacteria; 129 species of algae and 2 species of sea grasses, including 22% of green algae, 21% of brown algae, 51% of red algae, 6% of blue-green algae, were found in shallow coastal waters of Mot and Mieu islands on hard and soft bottoms. Depending on the area and quality of the substrate, fouling algae form polydominant turf communities, mono- and bidominant communities of crustose algae, or no specific communities. The flora of red, brown, and green fouling macroalgae and benthic macroalgae growing in the upper subtidal of Nha Trang Bay was generally similar to the flora of coral reefs of the Indo-West Pacific region. The taxonomic distributions of algae at the farms and on the bottom differed considerably at the levels of both orders and families. We suggest that the differences in the species diversity and species composition at the farms and on the bottom near these farms were mainly caused by the differences in the quality of the substrate.

Key words: fouling algae, benthic macroalgae, lobster farms, communities, turf algae, South China Sea, Nha Trang Bay.

The production of lobsters in cages located both offshore and in closed bays has been very profitable in the last 20 years, especially in Vietnam, India, and Philippines (Modayil et al., 2008). For example, Vietnam produces 1500 tons of fresh lobsters annually (Tuan, Mao, 2004), and India exports over 1000 tons of frozen lobsters a year (Modayil et al., 2008). In Vietnam, lobsters are grown in cages at farms located in closed bays. One of the most important problems facing lobster

producers is animal and plant fouling of submerged surfaces (especially net cages, where lobsters are kept). When underwater surfaces (ropes, lines, or plastic floats) are overgrown, they get heavier and may break off anchor ropes under stormy conditions. However, only heavy animals, like mollusks or corals, may constitute certain threat, as opposed to algae. Anti-fouling measures include manual cleaning and using of fouling-resistant materials and anti-fouling coatings. These measures help in preventing all fouling organisms, both animals and plants, from settling on the surfaces of farm structures (Watson et al., 2009). It should be noted that, although the negative impact of fouling animals on the functioning of lobster farms is obvious (they increase the weight of farm constructions and contaminate the bottom and water with dead organisms and products of their decomposition), the role of fouling algae (even epibionts) is not that clear in the functioning of both aquaculture farms and natural coastal biocenoses (Watson et al., 2009; Titlyanov, Titlyanova, 2010).

It may be suggested that in closed and semi-closed marine bays the algae growing on any submerged surfaces more likely exert positive than negative impact. They are positive in producing the major portion of organic matter and being at the first level of a food chain in an ecosystem. Marine plants store solar energy when synthesizing organic matter, enrich water with oxygen, and remove excess dissolved nitrogen- and phosphorus-containing nutrients accumulating in areas of intensive aquaculture (Fong, Paul, 2011).

On the other hand, some fouling algae, especially the green ones, may cause algal blooms and thus exert detrimental effect on the state of ecosystems. Basic study of the species composition and structure of communities of fouling algae is very important for defining the part these algae play in ecosystems disrupted by aquaculture, as well as their influence on the productivity and cost-effectiveness of aquaculture farms.

The goal of the present study is to compare the algal communities of fouling algae growing on submerged surfaces of aquaculture farms in Nha Trang Bay, South China Sea (Khanh Hoa Province, Vietnam) and natural bottom plant communities around these farms.

Material and methods

The structure of algal fouling communities was studied on the submerged surfaces of lobster farms in Nha Trang Bay, in semi-closed bays of Mot (station 1) and Che (station 2) islands (Figs. 1–3). At each farm there is one or several rafts made of plastic barrels fixed with wooden boards, bomboos, metal sticks, or ropes. A raft carries ten or more net cages with a diameter of 3–4 m reaching down to 7 m of depth. The rafts are anchored to the bottom with plastic ropes. The submerged

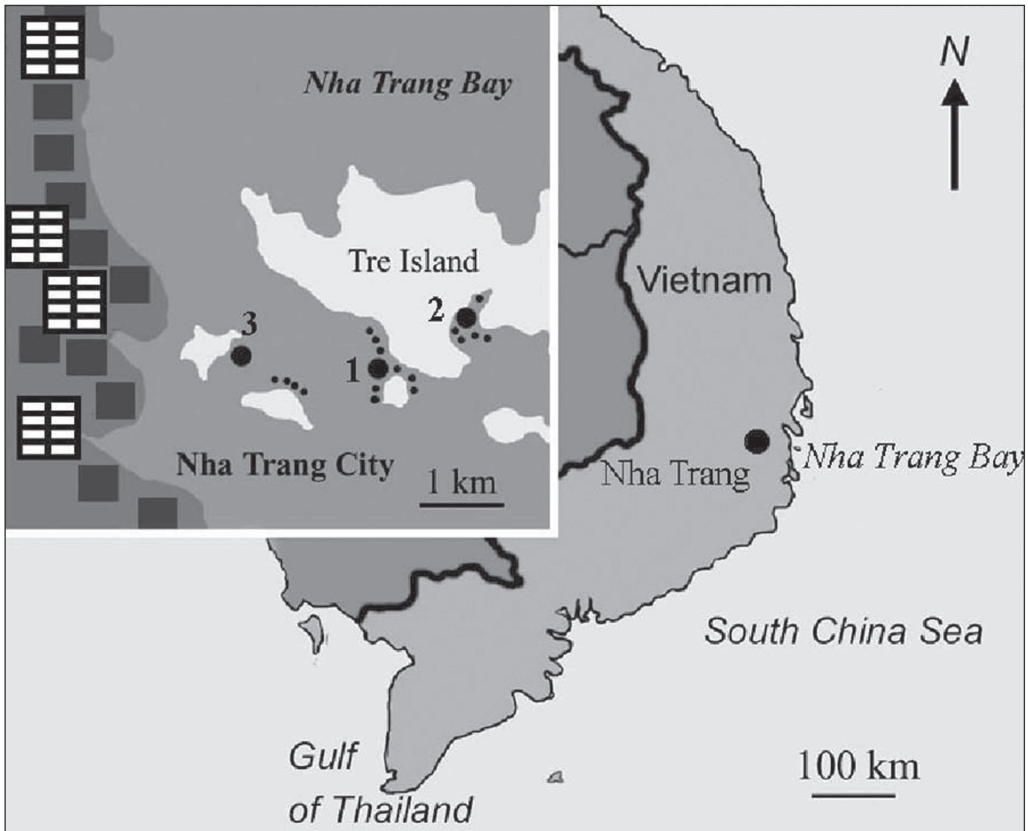


Fig. 1. Schematic map of the southern Vietnam showing the sites where the algae were collected. (1) Lobster farms, Mot Island; (2) Lobster farms, Che Island (Beach Dam); (3) Mieu Island. Legend:  lobster farms;  shrimp ponds.

surfaces of the raft include plastic barrels, ropes, lines, nets, wooden, bamboo, or metal parts. When the sea is rough, cages and the other submerged equipment are set in motion preventing accumulation of sediments and settlement of fouling organisms on their surfaces.

Natural bottom plant communities were studied along the coasts of Mot Island (50–100 m from aquaculture farms) and Mieu Island (1–2 km from aquaculture farms) (Fig. 1, station 3), at a depth of 0.5 to 2 m. The major bottoms of Nha Trang Bay are the carbonate basis of coral reefs, dead scleractinian coral colonies, fragments of coral colonies, shells of dead mollusks, and coral sand. The bottom (substrate) and the plants are greatly silted (see Figs. 14, 15, 17, 18), and in some places the silt and sand layer is up to 2–3 cm thick on the bottom and up to 1–2 mm thick on the algal thalluses.



Fig. 2. Station 1, lobster farms near Mot Island.



Fig. 3. Station 2, lobster farms near Che Island.

The studies at Mot Island farms and around them were conducted in April, 2006, 2007, 2008, 2009, and 2010, at Che Island farms in April, 2009. Altogether 15 collections of algae were carried out: 8 collections at the farms of Mot Island, 4 collections near Mot Island, 2 collections near Mieu Island (located close to Mot Island), and 1 collection at the farms of Che Island.

The authors collected and took pictures of algae using snorkeling equipment. The spatial coverage of the substrate by marine plants and animals was estimated by eye and by photos.

The algae collected were transferred to the laboratory and put into aerated aquaria, where they were kept for handling (taking pictures of the algae in an aquarium, under a microscope, and in air; and taxonomic identification). Part of the material was dried for herbarium right after collection, and the other part was fixed in 4% formaldehyde. The collected herbarium is deposited at the A.V. Zhirmunsky Institute of Marine Biology FEB RAS, Vladivostok, Russia.

Marine plants were identified live under optical microscopes. Identification was based on the following works (Lamouroux, 1809; Kützing, 1843, 1868; Børgesen, 1917, 1924, 1939, 1940, 1948; Rosenvinge, 1924; Setchell, Gardner, 1930; Taylor, 1950, 1960, 1966; Egerod, 1952; Dawson, 1954, 1956, 1957, 1961; Doty, Meñez, 1960; Durairatnam, 1961; Hollenberg, 1968; Trono, 1968; Pham-Hoàng, 1969; Jaasund, 1976; Reyes, 1976; Tseng, 1983; Womersley, 1984, 1987, 1994a, b; Penrose et al., 1991; Price, Scott, 1992; Maggs, Hommersand, 1993; Nguyễn Hữu Dinh et al., 1993; Wynne, 1993, 1995; Chamberlain, 1994; Huisman, 1996; Lewmanomort, 1997; Littler, Littler, 2000, 2003; Skelton, South, 2000; Abbott et al., 2002; Leliaert, Coppejans, 2003; Skelton, 2003; Tsutsui et al., 2005; Dawes, Mathieson, 2008). The systematics and nomenclature followed M.D. Guiry and G.M. Guiry (<http://www.algaebase.org>; searched on 25 November 2015).

Results

Farms

The algae were collected at the farms (Figs. 2, 3) from various artificial substrates: nets of cages (Fig. 4), plastic ropes and lines (Fig. 5), bumpers from car tyres (Fig. 6), plastic barrels (Fig. 7), shells of fouling mollusks (Fig. 8), metal constructions (Figs. 9, 10), and polyfoam floats (Fig. 11).

A total of 133 species of macroalgae and cyanobacteria were collected at the farms, including 29 species of Chlorophyta (22%), 24 of Ochrophyta (18%), 72 of Rhodophyta (54%), and 8 of Cyanobacteria (6.0%) (see Table).

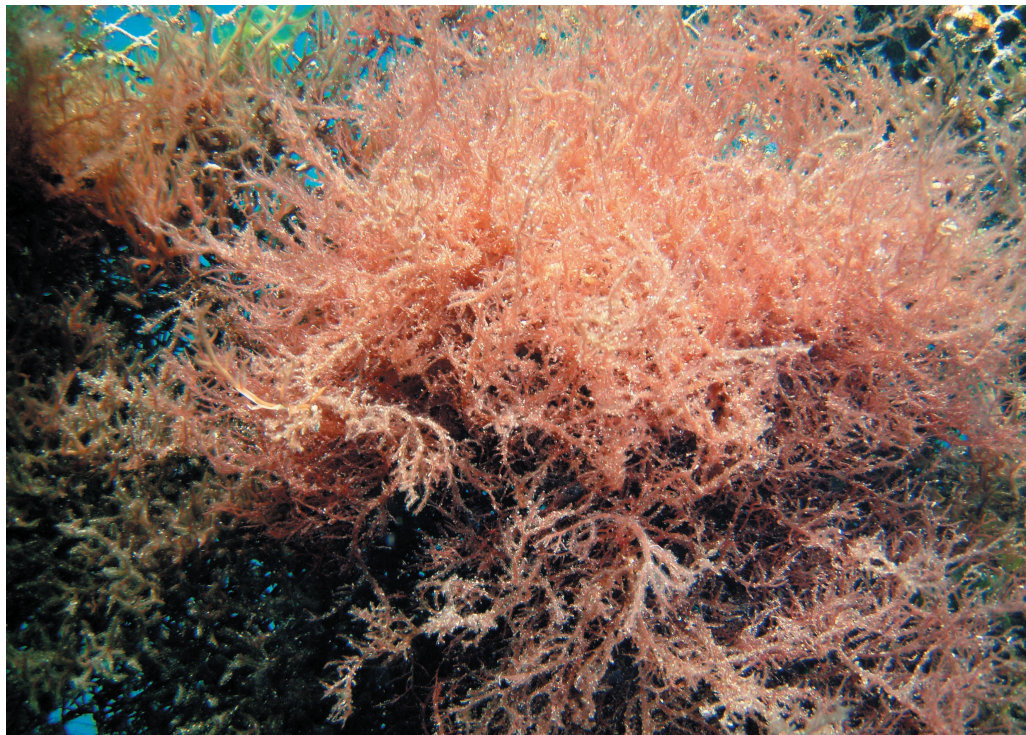


Fig. 4. *Hypnea valentiae* (Rh) on a lobster net cage. Station 1. Lobster farm near Mot Island, depth 0.7 m, April 9, 2008.



Fig. 5. *Chnoospora implexa* (Och) on a plastic rope of 5 cm in diameter. Station 1. Farm near Mot Island, depth 2 m, April 22, 2006.



Fig. 6. *Ulva papenfussii* (Ch) on a bumper made of a car tyre. Station 1. Farm near Mot Island, depth 0.7 m, April 9, 2006.



Fig. 7. Fouling of plastic barrels carrying net cages. Station 1. Farm near Mot Island, April 29, 2007.



Fig. 8. *Ulva reticulata* (Ch) and *Amphiroa fragilissima* (Rh) on scallop shells. Station 1. Farm near Mot Island, depth 1.5 m, April 9, 2008.

Green algae were represented by the species belonging to 5 orders: **Ulvales** (6 species of the family Ulvaceae, or 21% of all species; 1 species of Ulvellaceae, or 3%); order **Cladophorales** (6 species of Cladophoraceae, or 21%; 1 species of Anadyomenaceae, or 3%); order **Siphonocladales** (3 species of Boodleaceae, or 10%; 2 species of Derbesiaceae, or 7%; 1 species of Valoniaceae, or 3%); order **Bryopsidales** (2 species of Bryopsidaceae, or 7%; 2 species of Codiaceae, or 7%; 4 species of Caulerpacae, or 14%); order **Dasycladales** (1 species of Dasycladaceae, or 3%).

Brown algae were represented by: order **Ectocarpales** (1 species of Acinetosporaceae, or 4%); **Ralfsiales** (1 species of Neoralfsiaceae, or 4%); **Scytosiphonales** (5 species of Scytosiphonaceae, or 22%); **Sphacelariales** (2 species of Sphacelariaceae, or 8%); **Dictyotales** (8 species of Dictyotaceae, or 35%); **Fucales** (7 species of Sargassaceae, or 29%).

Red algae were most numerous at the farms, and their taxonomic distribution was as follows: **Stylonematales** (1 species of Stylonemataceae, or 1%); **Erythropeltidales** (2 species of Erythrotrichiaceae, or 3%); **Acrochaetiales** (1 species of Acrochaetiaceae, or 1%); **Colaconematales** (1 species of Colaconemataceae, or 1%);

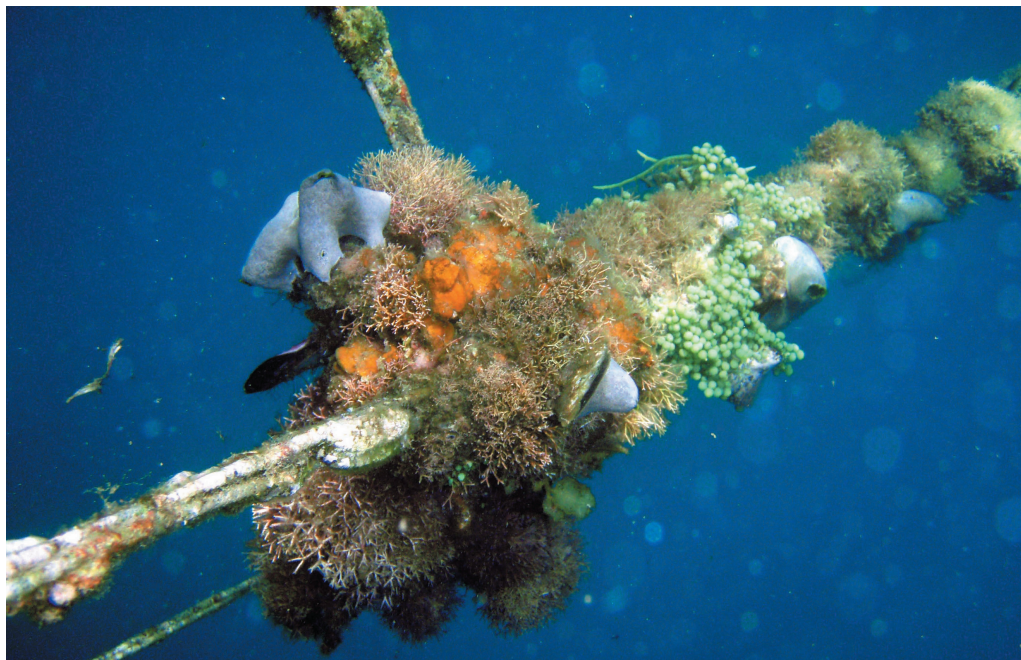


Fig. 9. *Amphiroa fragilissima* (Rh) and *Caulerpa racemosa* (Ch) on metal structures. Station 1. Farm near Mot Island, depth 1.5 m, April 9, 2008.



Fig. 10. *Acanthophora spicifera* (Rh) on a steel rope. Station 2. Farm near Che Island, depth 1.5 m, April 3, 2009.

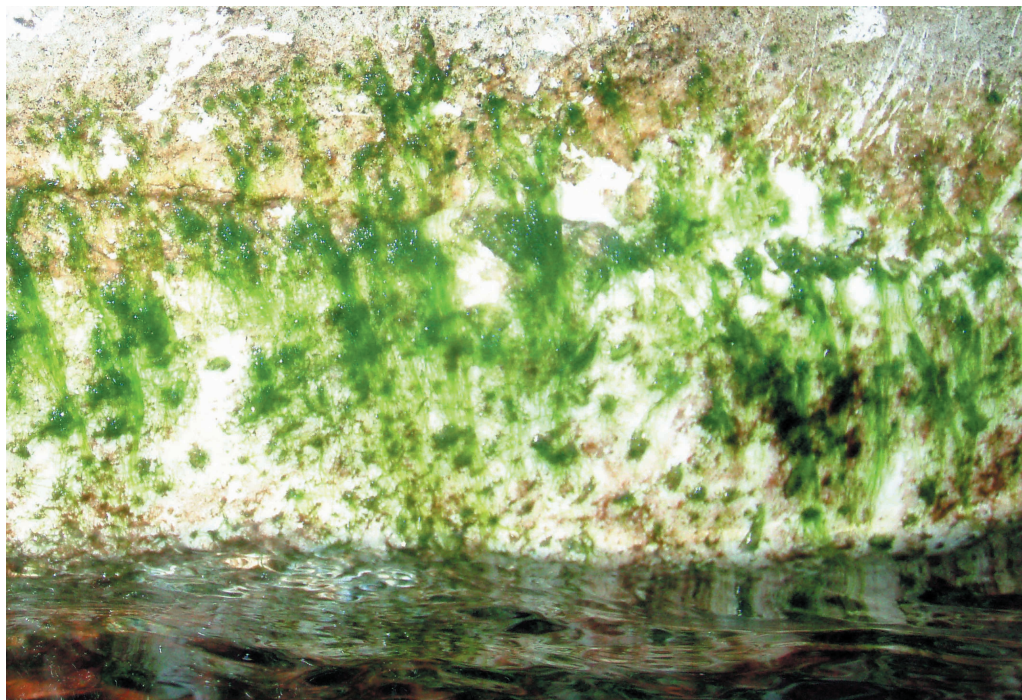


Fig. 11. *Ulva flexuosa* (Ch) on a polyfoam float. Station 1. Farm near Mot Island, April 26, 2008.

Nemaliales (3 species of Galaxauraceae, or 4%); **Hildenbrandiales** (1 species of Hildenbrandiaceae, or 1%); **Corallinales** (9 species of Corallinaceae, or 12%); **Gelidiales** (2 species of Gelidiaceae, or 3%; 2 species of Gelidiellaceae, or 3%; 1 species of Pterocladiaceae, or 1%); **Bonnemaisoniales** (2 species of Bonnemaisoniaceae, or 3%); **Gigartinales** (5 species of Cystocloniaceae, or 7%; 1 species of Peyssonneliaceae, or 1%); **Gracilariales** (2 species of Gracilariaceae, or 3%); **Rhodymeniales** (1 species of Champiaceae, or 1%; 2 species of Lomentariaceae, or 3%; 1 species of Rhodymeniaceae, or 1%); **Ceramiales** (10 species of Ceramiaceae, or 13%; 1 species of Dasyaceae, or 1%; 4 species of Delesseriaceae, or 6%; 13 species of Rhodomelaceae, or 18%; 1 species of Spyridiaceae, or 1%; 5 species of Wrangeliaceae, or 7%).

Cyanobacteria of the following orders were found on the submerged surfaces of the farms: **Oscillatoriales** 6 species, **Nostocales** 2 species, and **Spirulinales** 1 species.

The most abundant of the all algae found were: *Ulva flexuosa* Wulfen (Fig. 11), *Ulva reticulata* Forsskål (Fig. 8), *Bryopsis pennata* J.V. Lamouroux, *B. plumosa* (Hudson) C. Agardh, *Caulerpa racemosa* (Forsskål) J. Agardh (Fig. 9), *C. nummularia* Harvey ex J. Agardh, *Caulerpa chemnitzia* (Esper) J.V. Lamouroux (= *C. peltata* J.V. Lamouroux)

Species composition and abundance of the marine plants found on the surfaces of lobster farms and on the bottom of Nha Trang Bay near the farms

Algal species	Abundance of fouling algae at the farms	Abundance of benthic plants
CHLOROPHYTA		
Order ULVALES		
Family Ulvaceae		
<i>Ulva chaetomorphoides</i> (Børgesen) Hayden, Blomster, Maggs, P.C. Silva, M.J. Stanhope et J.R. Waaland	+	+
<i>Ulva clathrata</i> (Roth) C. Agardh	+ E	
<i>Ulva compressa</i> Linnaeus	+	++
<i>Ulva flexuosa</i> Wulfen	+	
<i>Ulva lactuca</i> Linnaeus		++
<i>Ulva papenfussii</i> Pham-Hoàng Hô	++	
<i>Ulva reticulata</i> Forsskål	+++	++
Family Ulvellaceae		
<i>Entocladia viridis</i> Reinke	+	
Order CLADOPHORALES		
Family Cladophoraceae		
<i>Chaetomorpha capillaris</i> (Kützinger) Børgesen	+	
<i>Chaetomorpha indica</i> (Kützinger) Kützinger	+	
<i>Chaetomorpha linum</i> (O.F. Müller) Kützinger		+
<i>Cladophora flexuosa</i> (O.F. Müller) Kützinger	+	
<i>Cladophora laetevirens</i> (Dillwyn) Kützinger	+	
<i>Cladophora vagabunda</i> (Linnaeus) Hoek	+	+
<i>Rhizoclonium riparium</i> (Roth) Harvey [= <i>Rhizoclonium implexum</i> (Dillwyn) Kützinger]	+	+
Family Anadyomenaceae		
<i>Microdictyon okamurai</i> Setchell	+	+
Family Boodleaceae		
<i>Boodlea composita</i> (Harvey) F. Brand	++	+
<i>Cladophoropsis sundanensis</i> Reinbold	+	+
<i>Phyllocladion anastomosans</i> (Harvey) Kraft et M.J. Wynne	+	+
Family Siphonocladaceae		
<i>Dictyosphaeria cavernosa</i> (Forsskål) Børgesen		+
<i>Dictyosphaeria versluisii</i> Weber-van Bosse		+

Table (Continued)

Algal species	Abundance of fouling algae at the farms	Abundance of benthic plants
Family Valoniaceae		
<i>Valonia utricularis</i> (Roth) C. Agardh		+
<i>Valonia ventricosa</i> J. Agardh	+	+
Order BRYOPSIDALES		
Family Derbesiaceae		
<i>Derbesia attenuata</i> E.Y. Dawson	+	
<i>Derbesia fastigiata</i> W.R. Taylor	+	
Family Bryopsidaceae		
<i>Bryopsis pennata</i> J.V. Lamouroux	++	
<i>Bryopsis plumosa</i> (Hudson) C. Agardh	+++	
Family Codiaceae		
<i>Codium geppiorum</i> O.C. Schmidt	S	
<i>Codium repens</i> P. Crouan et H. Crouan	+	+
Family Caulerpaceae		
<i>Caulerpa chemnitzia</i> (Esper) J.V. Lamouroux	+++	
<i>Caulerpa fastigiata</i> Montagne		+
<i>Caulerpa microphysa</i> (Weber-van Bosse) Feldmann	+	
<i>Caulerpa nummularia</i> Harvey ex J. Agardh	++	
<i>Caulerpa racemosa</i> (Forsskål) J. Agardh	++	++
<i>Caulerpa serrulata</i> (Forsskål) J. Agardh		++
Family Halimedaceae		
<i>Halimeda cuneata</i> f. <i>digitata</i> E.S. Barton		+
<i>Halimeda discoidea</i> Decaisne		+++
<i>Halimeda opuntia</i> (Linnaeus) J.V. Lamouroux		++
Family Udoteaceae		
<i>Penicillus sibogae</i> A. Gepp et E.S. Gepp		+
<i>Rhipidosiphon javensis</i> Montagne		++
Order DASYCLADALES		
Family Dasycladaceae		
<i>Bornetella sphaerica</i> (Zanardini) Solms-Laubach		+
<i>Neomeris bilimbata</i> J.T. Koster	S	
Family Polyphysaceae		
<i>Parvocaulis clavatus</i> (Yamada) S. Berger, U. Fettweiss, S. Gleissberg, L.B. Liddle, U. Richter, H. Sawitzky et G.C. Zuccarello		+

Table (Continued)

Algal species	Abundance of fouling algae at the farms	Abundance of benthic plants
<i>Parvocaulis exiguus</i> (Solms-Laubach) S. Berger, Fettweiss, Gleissberg, Liddle, U. Richter, Sawitzky et Zuccarello		+
<i>Parvocaulis parvulus</i> (Solms-Laubach) S. Berger, Fettweiss, Gleissberg, Liddle, U. Richter, Sawitzky et Zuccarello		++
<i>Parvocaulis pusillus</i> (M. Howe) S. Berger, U. Fettweiss, S. Gleissberg, L.B. Liddle, U. Richter, H. Sawitsky et G.C. Zuccarello		+
OCHROPHYTA		
Order ECTOCARPALES		
Family Acinetosporaceae		
<i>Feldmannia mitchelliae</i> (Harvey) H.-S. Kim	+++	++
Family Scytosiphonaceae		
<i>Chnoospora implexa</i> J. Agardh	+	++
<i>Colpomenia sinuosa</i> (Mertens ex Roth) Derbès et Solier	++	++
<i>Hydroclathrus clathratus</i> (C. Agardh) M. Howe	++	++
<i>Rosenvingea intricata</i> (J. Agardh) Børgesen	++	++
<i>Rosenvingea orientalis</i> (J. Agardh) Børgesen	+	+
Order RALFSIALES		
Family Neoralfsiaceae		
<i>Neoralfsia expansa</i> (J. Agardh) P.-E. Lim et H. Kawai ex Cormaci et G. Furnari [= <i>Ralfsia expansa</i> (J. Agardh) J. Agardh]	+	++
Order SPHACELARIALES		
Family Sphacelariaceae		
<i>Sphacelaria novae-hollandiae</i> Sonder		+
<i>Sphacelaria rigidula</i> Kützinger	+ E	+ E
<i>Sphacelaria tribuloides</i> Meneghini	+ E	+
Order DICTYOTALES		
Family Dictyotaceae		
<i>Canistrocarpus cervicornis</i> (Kützinger) De Paula et De Clerck	+	+
<i>Dictyopteris delicatula</i> J.V. Lamouroux		+
<i>Dictyota bartayresiana</i> J.V. Lamouroux	+	+
<i>Dictyota dichotoma</i> (Hudson) J.V. Lamouroux	++	+
<i>Dictyota friabilis</i> Setchell	+++	++

Table (Continued)

Algal species	Abundance of fouling algae at the farms	Abundance of benthic plants
<i>Dictyota implexa</i> (Desfontaines) J.V. Lamouroux [= <i>Dictyota divaricata</i> J.V. Lamouroux, <i>Dictyota linearis</i> (C. Agardh) Greville]	+	++
<i>Dictyota spinulosa</i> J.D. Hooker et Arnott	+	
<i>Lobophora variegata</i> (J.V. Lamouroux) Womersley ex E.C. Oliveira	++	++
<i>Padina australis</i> Hauck	+	+
<i>Padina boryana</i> Thivy		++
<i>Padina gymnospora</i> (Kützinger) Sonder [= <i>Padina crassa</i>]		+
Order FUCALES		
Family Sargassaceae		
<i>Sargassum aquifolium</i> (Turner) C. Agardh [= <i>Sargassum crassifolium</i> J. Agardh, <i>Sargassum binderi</i> Sonder ex J. Agardh]	+	+
<i>Sargassum ilicifolium</i> (Turner) C. Agardh [= <i>Sargassum duplicatum</i> Bory de Saint-Vincent]	+	
<i>Sargassum mclurei</i> Setchell	+	+++
<i>Sargassum microcystum</i> J. Agardh	+	+++
<i>Sargassum miyabei</i> Yendo	+	+
<i>Sargassum oligocystum</i> Montagne		+++
<i>Sargassum polycystum</i> C. Agardh	+	+++
<i>Turbinaria ornata</i> (Turner) J. Agardh	+	+++
RHODOPHYTA		
Order STYLONEMATALES		
Family Stylonemataceae		
<i>Chroodactylon ornatum</i> (C. Agardh) Basson		+ E
<i>Stylonema alsidii</i> (Zanardini) K.M. Drew	++ E	+ E
Order ERYTHROPELTIDALES		
Family Erythrotrichiaceae		
<i>Erythrotrichia carnea</i> (Dillwyn) J. Agardh	+++ E	+ E
<i>Sablingia subintegra</i> (Rosenvinge) Kornmann	+ E	+ E
Order ACROCHAETIALES		
Family Acrochaetiaceae		
<i>Acrochaetium catenulatum</i> M.A. Howe	+ E	+ E
Order COLACONEMATALES		
Family Colaconemataceae		
<i>Colaconema hypneae</i> (Børgesen) A.A. Santos et C.W.N. Moura	+ E	+ E

Table (Continued)

Algal species	Abundance of fouling algae at the farms	Abundance of benthic plants
Order NEMALIALES		
Family Liagoraceae		
<i>Ganonema farinosum</i> (J.V. Lamouroux) K.C. Fan et Yung C. Wang		++
<i>Liagora ceranoides</i> J.V. Lamouroux		++
Family Yamadaellaceae		
<i>Yamadaella caenomyce</i> (Decaisne) I.A. Abbott		++
Family Galaxauraceae		
<i>Actinotrichia fragilis</i> (Forsskål) Børgesen	++	+
<i>Galaxaura divaricata</i> (Linnaeus) Huisman et R.A. Townsend [= <i>Galaxaura fasciculata</i> Kjellman]		+
<i>Galaxaura filamentosa</i> R.C.Y. Chou	+	
<i>Tricleocarpa cylindrica</i> (J. Ellis et Solander) Huisman et Borowirzka	+	+
Order HILDENBRANDIALES		
Family Hildenbrandiaceae		
<i>Hildenbrandia rubra</i> (Sommerfelt) Meneghini	+	+
Order CORALLINALES		
Family Corallinaceae		
<i>Amphiroa beauvoisii</i> J.V. Lamouroux	+	
<i>Amphiroa foliacea</i> J.V. Lamouroux	+	++
<i>Amphiroa fragilissima</i> (Linnaeus) J.V. Lamouroux	+++	+++
* <i>Hydrolithon boreale</i> (Foslie) Y.M. Chamberlain	+ E	
<i>Hydrolithon farinosum</i> (J.V. Lamouroux) Penrose et Y.M. Chamberlain	+ E	++ E
<i>Jania adhaerens</i> J.V. Lamouroux	+ E	+
<i>Jania capillacea</i> Harvey	+	+
<i>Jania unguolata</i> f. <i>brevior</i> (Yendo) Yendo	+	+
* <i>Pneophyllum fragile</i> Kützinger	++ E	+ E
Order HAPALIDIALES		
Family Hapalidiaceae		
<i>Mesophyllum erubescens</i> (Foslie) M. Lemoine		+
Order GELIDIALES		
Family Gelidiaceae		
<i>Gelidium pulchellum</i> (Turner) Kützinger	+	
<i>Gelidium pusillum</i> (Stackhouse) Le Jolis	+ E	+

Table (Continued)

Algal species	Abundance of fouling algae at the farms	Abundance of benthic plants
Family Gelidiellaceae		
<i>Gelidiella acerosa</i> (Forsskål) Feldmann et G. Hamel	+ E	+
<i>Parviphycus pannosus</i> (Feldmann) G. Furnari [= <i>Gelidiella tenuissima</i> Feldmann et G. Hamel]	+	+
Family Pterocladiaceae		
<i>Pterocladia caerulescens</i> (Kützinger) Santelices et Hommersand	+	
Order BONNEMAISONIALES		
Family Bonnemaisioniaceae		
<i>Asparagopsis taxiformis</i> (Delile) Trevisan de Saint-Léon	+	++
<i>A. taxiformis</i> (Delile) Trevisan de Saint-Léon (<i>Falkenbergia</i> -phase)	+++ E	+
Order GIGARTINALES		
Family Cystocloniaceae		
<i>Hypnea aspera</i> Kützinger [= <i>Hypnea boergesenii</i> T. Tanaka]	+	+
<i>Hypnea nidulans</i> Setchell	++ F	
<i>Hypnea pannosa</i> J. Agardh	++	++
<i>Hypnea spinella</i> (C. Agardh) Kützinger	++ F	
<i>Hypnea valentiae</i> (Turner) Montagne	++	+
Order PEYSSONNELIALES		
Family Peyssonneliaceae		
<i>Peyssonnelia conchicola</i> Piccone et Grunow	+	+
<i>Peyssonnelia rubra</i> (Greville) J. Agardh		+
<i>Peyssonnelia</i> sp.		+
Order GRACILARIALES		
Family Gracilariaceae		
<i>Gracilaria arcuata</i> Zanardini		S
<i>Gracilaria edulis</i> (S.G. Gmelin) P.C. Silva	+++ F	++
<i>Gracilaria eucheumatoides</i> Harvey		+
<i>Gracilaria salicornia</i> (C. Agardh) E.Y. Dawson	+	++
Order RHODYMENIALES		
Family Champiaceae		
<i>Champia parvula</i> (C. Agardh) Harvey	+ E	+ E
Family Lomentariaceae		
<i>Ceratodictyon intricatum</i> (C. Agardh) R.E. Norris	+	++
<i>Ceratodictyon spongiosum</i> Zanardini		+++
* <i>Lomentaria corallicola</i> Børgesen	+ T	+

Table (Continued)

Algal species	Abundance of fouling algae at the farms	Abundance of benthic plants
Family Rhodymeniaceae		
* <i>Chamaebotrys boergesenii</i> (Weber-van Bosse) Huisman	+	
Order CERAMIALES		
Family Callithamniaceae		
<i>Crouania attenuata</i> (C. Agardh) J. Agardh [= <i>Crouania minutissima</i> Yamada]		+
Family Ceramiaceae		
* <i>Antithamnion antillanum</i> Børgesen	+ E	
<i>Centroceras clavulatum</i> (C. Agardh) Montagne	+++ T, F	+
<i>Centroceras gasparrinii</i> (Meneghini) Kützinger [= <i>Centroceras inerme</i> Kützinger]	+ E	
<i>Ceramium aduncum</i> Nakamura	+ T	
<i>Ceramium cimbricum</i> H.E. Petersen [= <i>Ceramium fastigiatum</i> Harvey]	+	+ E, T
<i>Ceramium cingulatum</i> Weber-van Bosse	+ E	
<i>Ceramium macilentum</i> J. Agardh	+ T	
<i>Ceramium procumbens</i> Setchell et N.L. Gardner	+ E, T	+ E, T
<i>Corallophila kleiwegii</i> Weber-van Bosse [= <i>Centroceras apiculatum</i> Yamada; <i>Corallophila apiculata</i> (Yamada) R.E. Norris]	+ E	
<i>Gayliella fimbriata</i> (Setchell et N.L. Gardner) T.O. Cho et S.M. Boo [= <i>Ceramium fimbriatum</i> Setchell et N.L. Gardner]		+ E, T
<i>Gayliella flaccida</i> (Harvey ex Kützinger) T.O. Cho et L.J. McIvor	+++ T, E	+ T
Family Dasyaceae		
* <i>Heterosiphonia crispella</i> (C. Agardh) M.J. Wynne	+++ E, T	+
<i>Heterosiphonia</i> sp.		++
Family Delesseriaceae		
<i>Hypoglossum attenuatum</i> N.L. Gardner	+ E	+
* <i>Hypoglossum caloglossoides</i> M.J. Wynne et Kraft	+ E	
<i>Hypoglossum</i> sp.	+ E	
* <i>Martensia fragilis</i> Harvey [= <i>Martensia pavonia</i> (J. Agardh) J. Agardh]		+ E S
<i>Taenioma perpusillum</i> (J. Agardh) J. Agardh	+ E	+
Family Rhodomelaceae		
<i>Acanthophora muscoides</i> (Linnaeus) Bory	+	++ F

Table (Continued)

Algal species	Abundance of fouling algae at the farms	Abundance of benthic plants
<i>Acanthophora spicifera</i> (M. Vahl) Børgesen	+++ F	++
<i>Chondria repens</i> Børgesen	+ E	
<i>Chondria</i> sp.	+	
<i>Chondrophycus concretus</i> (A.B. Cribb) K.W. Nam [= <i>Laurencia concreta</i> A.B. Cribb]	+	++
* <i>Endosiphonia horrida</i> (C. Agardh) P.C. Silva		+
<i>Herposiphonia parca</i> Setchell	+	
<i>Herposiphonia secunda</i> (C. Agardh) Ambronn	+ E	++
<i>Herposiphonia secunda</i> f. <i>tenella</i> (C. Agardh) M.J. Wynne	++ E	
<i>Laurencia obtusa</i> (Hudson) J.V. Lamouroux		+
<i>Leveillea jungermannioides</i> (Hering et G. Martens) Harvey		+++ E
<i>Neosiphonia sphaerocarpa</i> (Børgesen) M.S. Kim et I.K. Lee [= <i>Polysiphonia sphaerocarpa</i> Børgesen]	+ E	
<i>Palisada parvipapillata</i> (C.K. Tseng) K.W. Nam [= <i>Laurencia parvipapillata</i> C.K. Tseng]	+	+
<i>Palisada perforata</i> (Bory) K.W. Nam		++
<i>Polysiphonia scopulorum</i> var. <i>villum</i> (J. Agardh) Hollenberg [= <i>Lophosiphonia villum</i> (J. Agardh) Setchell et N.L. Gardner]	+ E, T	+ E
<i>Polysiphonia subtilissima</i> Montagne	+ E	
<i>Tolypocladia glomerulata</i> (C. Agardh) F. Schmitz	+ E	+
Family Spyridiaceae		
<i>Spyridia filamentosa</i> (Wulfen) Harvey	+++ T	+
Family Wrangeliaceae		
<i>Anotrichium tenue</i> (C. Agardh) Nägeli	+	+
<i>Griffithsia japonica</i> Okamura	+ T	
<i>Griffithsia metcalfii</i> C.K. Tseng	+ T	
<i>Pleonosporium borrieri</i> (Smith) Nägeli	+ E	
<i>Spermothamnion</i> sp.	+ E	
* <i>Tiffaniella saccorhiza</i> (Setchell et N.L. Gardner) Doty et Meñez [= <i>Pleonosporium saccorhiza</i> Setchell et N.L. Gardner; <i>Spermothamnion saccorhiza</i> (Setchell et N.L. Gardner) Feldmann- Mazoyer]	+ E	
<i>Wrangelia argus</i> (Montagne) Montagne		+

Table (Continued)

Algal species	Abundance of fouling algae at the farms	Abundance of benthic plants
CYNOBACTERIA		
Order NOSTOCALES		
Family Symphyonemataceae		
<i>Brachytrichia quoyi</i> Bornet et Flahault		+++
Family Tolypothrichaceae		
<i>Tolypothrix distorta</i> Kützing ex Bornet et Flahault	+	
Family Rivulariaceae		
<i>Calothrix confervicola</i> C. Agardh ex Bornet et Flahault		+
* <i>Dichothrix penicillata</i> Zanardini ex Bornet et Flahault	+	+
Order OSCILLATORIALES		
Family Oscillatoriaceae		
<i>Lyngbya majuscula</i> Harvey ex Gomont	+	++
<i>Lyngbya semiplena</i> J. Agardh ex Gomont		++
<i>Lyngbya sordida</i> Gomont		+
<i>Oscillatoria limosa</i> C. Agardh ex Gomont	+	
<i>Oscillatoria miniata</i> (Zanardini) Hauck ex Gomont	+	
<i>Phormidium corium</i> (C. Agardh) Kützing ex Gomont	+++	
Family Microcoleaceae		
<i>Symploca hydroides</i> Kützing ex Gomont	++	
Order SPIRULINALES		
Family Spirulinaceae		
<i>Spirulina major</i> Kützing ex Gomont	+	
<i>Spirulina subtilissima</i> Kützing ex Gomont		+
TRACHEOPHYTA		
Order ALISMATALES		
Family Cymodoceaceae		
<i>Halodule uninervis</i> (Forsskål) Ascherson		+
Family Hydrocharitaceae		
<i>Thalassia hemprichii</i> (Ehrenberg) Ascherson		+++

Notes. (+++) abundant species occupying over 50% of the substrate; (++) common species occurring everywhere; (+) rare species; (S) species found singly; (F) female; (T) tetrasporophyte; (E) epiphyte.

*New records for Vietnam.

(Chlorophyta); *Dictyota friabilis* Setchell, *Feldmannia mitchelliae* (Harvey) H.-S. Kim, *Colpomenia sinuosa* (Mertens ex Roth) Derbès et Solier, *Hydroclathrus clathratus* (C. Agardh) M.A. Howe, *Rosenvingea intricata* (J. Agardh) Børgesen, *Chnoospora implexa* J. Agardh (Fig. 5) (Ochrophyta); *Centroceras clavulatum* (C. Agardh) Montagne, *Gracilaria edulis* (S.G. Gmelin) P.C. Silva, *Hypnea nidulans* Setchell, *H. pannosa* J. Agardh, *H. spinella* (C. Agardh) Kützing, *H. valentiae* (Turner) Montagne (Fig. 4), *Spyridia filamentosa* (Wulfen) Harvey, *Heterosiphonia crispella* (C. Agardh) M.J. Wynne (Rhodophyta), and *Phormidium corium* (C. Agardh) Kützing ex Gomont (Cyanobacteria). *Neomeris bilimbata* J.T. Koster and *Codium geppiorum* O.C. Schmidt (Chlorophyta) were found singly.

Benthic algae

A total of 129 species of algae and 2 species of sea grasses, including 29 species (22%) of green algae, 27 species (21%) of brown algae, 65 species (51%) of red algae, 8 species (6%) of blue-green algae, were found in shallow coastal waters of Mot and Mieu islands on hard and soft bottoms.

Green algae were represented by members of the following orders: **Ulvales** (4 species of Ulvaceae, or 13%); **Cladophorales** (3 species of Cladophoraceae, or 10%; 1 species of Anadyomenaceae, or 3%; 3 species of Boodleaceae, or 10%; 2 species of Siphonocladaceae, or 6%; 2 species of Valoniaceae, or 6%); **Bryopsidales** (1 species of Codiaceae, or 3%; 3 species of Caulerpacae, or 10%; 3 species of Halimedaceae, or 10%; 2 species of Udoteaceae, or 6%); **Dasycladales** (1 species of Dasycladaceae, or 3%; 4 species of Polyphysaceae, or 13%).

Brown algae were comprised of: **Ectocarpales** (1 species of Acinetosporaceae or 4%); **Ralfsiales** (1 species of Neoralfsiaceae, or 4%); **Scytosiphonales** (5 species of Scytosiphonaceae, or 20%); **Sphacelariales** (3 species of Sphacelariaceae, or 11%); **Dictyotales** (10 species of Dictyotaceae, or 37%); **Fucales** (7 species of Sargassaceae, or 24%).

The red algae found were taxonomically distributed as follows: **Stylonematales** (2 species of Stylonemataceae, or 3%); **Erythropeltidales** (2 species of Erythrotrichiaceae, or 3%); **Acrochaetiales** (2 species of Acrochaetiaceae, or 3%); **Nemaliales** (2 species of Liagoraceae, or 3%; 4 species of Galaxauraceae, or 6%); **Hildenbrandiales** (1 species of Hildenbrandiaceae, or 1%); **Corallinales** (7 species of Corallinaceae, or 11%); **Gelidiales** (1 species of Gelidiaceae, or 1%; 2 species of Gelidiellaceae, or 3%); **Bonnemaisoniales** (2 species of Bonnemaisoniaceae, or 3%); **Gigartinales** (3 species of Cystocloniaceae, or 7%; 3 species of Peyssonneliaceae, or 1%); **Gracilariales** (4 species of Gracilariaceae, or 6%); **Rhodymeniales** (1 species of Champiaceae, or 1%; 3 species of Lomentariaceae, or 3%); **Ceramiales** (1 species of Callithamniaceae, or 1%; 7 species of Ceramiaceae, or 11%; 2 species of Dasyaceae,

or 3%; 2 species of Delesseriaceae, or 3%; 11 species of Rhodomelaceae, or 17%; 1 species of Spyridiaceae, or 1%; 2 species of Wrangeliaceae, or 3%).

Cyanobacteria of the following orders were found on the bottom: **Nostocales** 2 species, **Oscillatoriales** 5 species, **Spirulinales** 1 species.

Two species of sea grasses were collected from soft bottoms: *Halodule uninervis* (Forsskål) Ascherson and *Thalassia hemprichii* (Ehrenberg) Ascherson.

The following species of algae were abundant on the bottom: *Ulva reticulata*, *Caulerpa serrulata* (Forsskål) J. Agardh, *Halimeda discoidea* (Chlorophyta), *Sargassum* spp. (Fig. 13), *Turbinaria ornata* (Turner) J. Agardh (Fig. 14), *Chnoospora implexa*, *Colpomenia sinuosa*, *Neoralsia expansa* (J. Agardh) P.-E. Lim et H. Kawai ex Kraft (Fig. 12) (Ochrophyta), *Amphiroa foliacea* J.V. Lamouroux (Fig. 15), *A. fragilissima* (Linnaeus) J.V. Lamouroux, *Ceratodictyon spongiosum* Zanardini, *Ganonema farinosum* (J.V. Lamouroux) K.C. Fan et Yung C. Wang (Fig. 16) (Rhodophyta), *Brachytrichia quoyi* Bornet et Flahault (Fig. 17) (Cyanobacteria). The beds of sea grasses *Thalassia hemprichii* and *Halodule uninervis* (Fig. 18) were frequently found on soft bottoms.

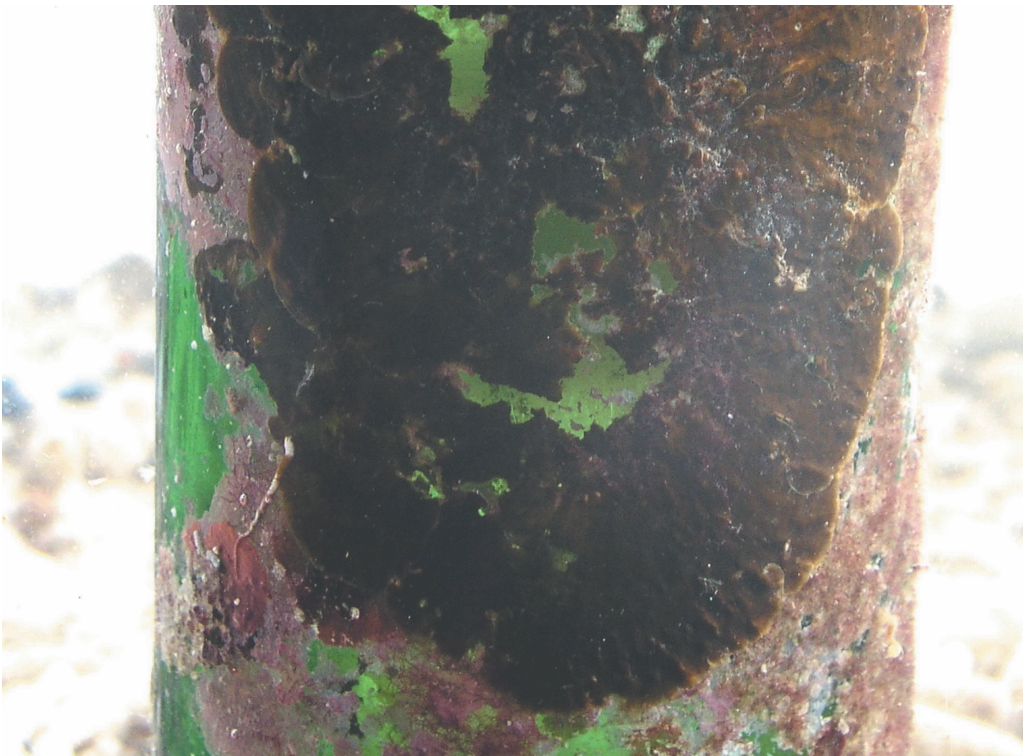


Fig. 12. *Neoralsia expansa* (Och) on a glass bottle. Station 3. Bottom near the farms, Mot Island, depth 2 m, April 22, 2008.

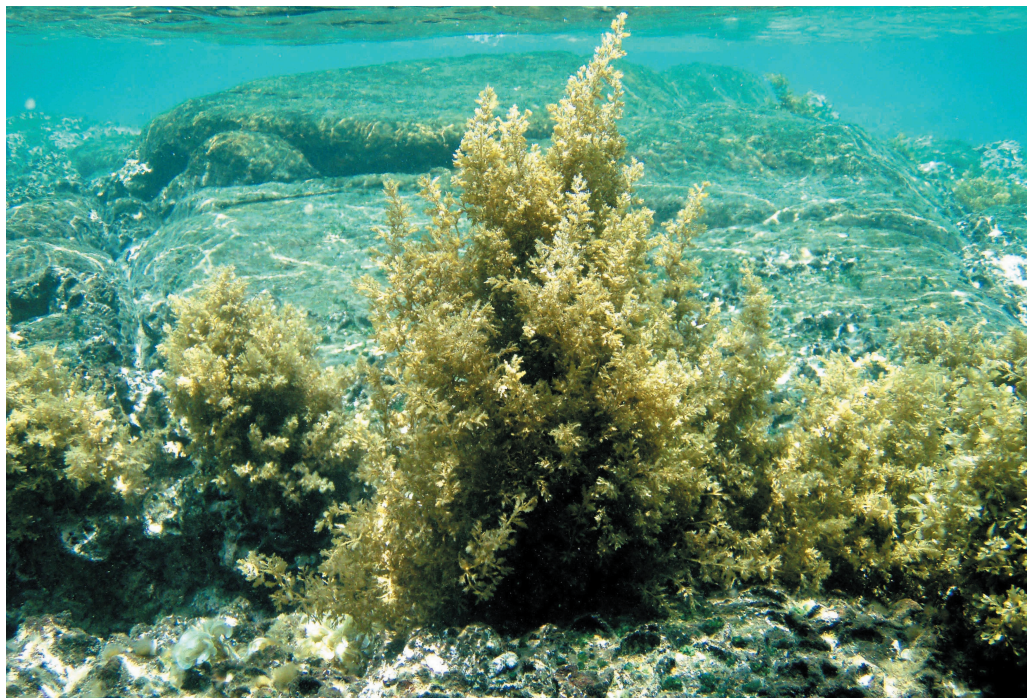


Fig. 13. *Sargassum polycystum* (Och) on the rocky bottom. Station 1. Bottom near the farms, Mot Island, depth 1 m, April 9, 2008.

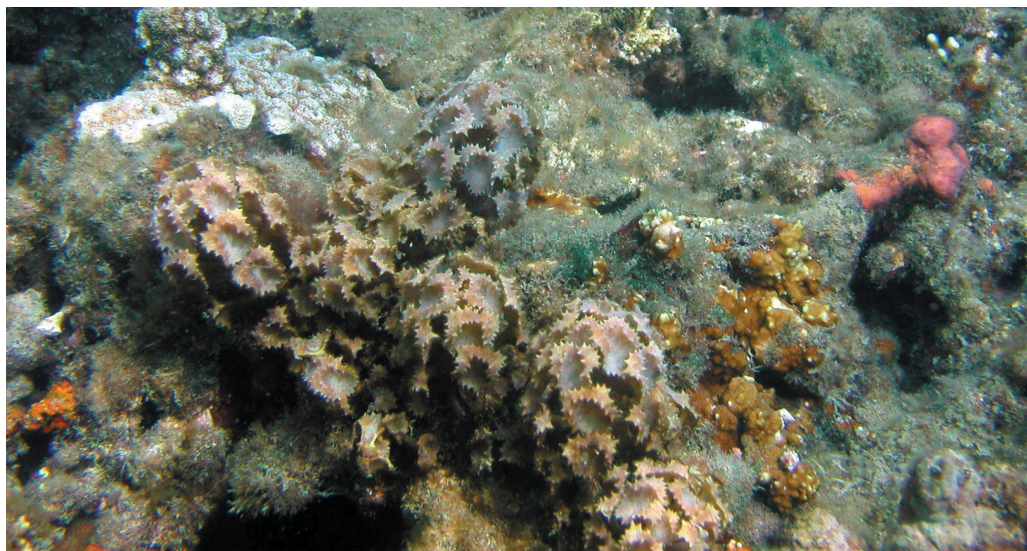


Fig. 14. *Turbinaria ornata* (Och) on dead coral colonies. Station 1. Bottom near the farms, Mot Island, depth 1.5 m, April 9, 2008.

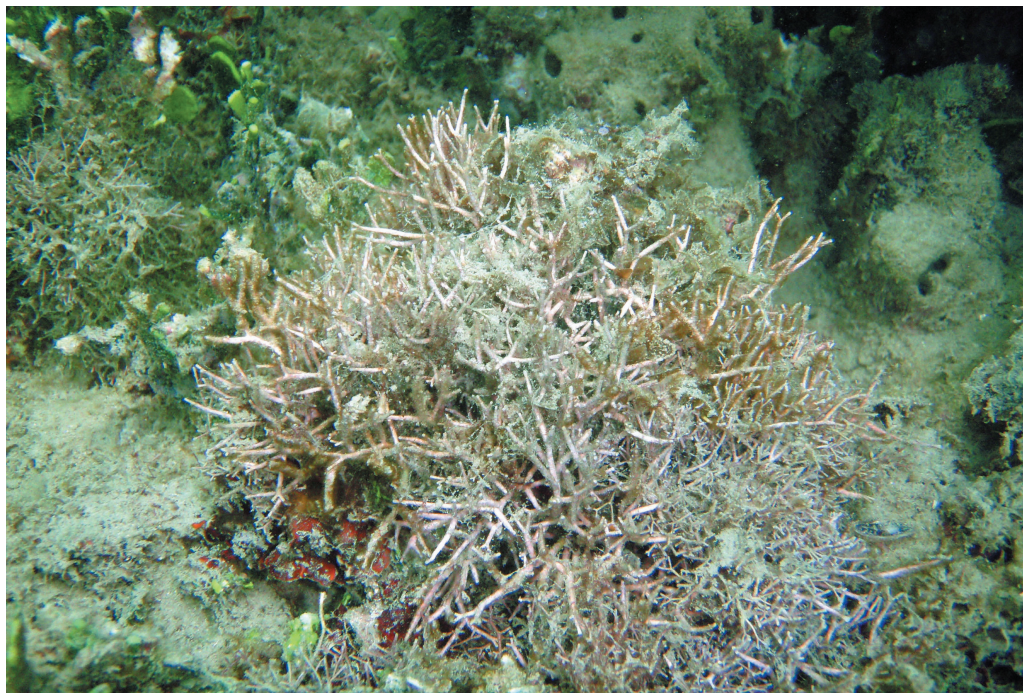


Fig. 15. *Amphiroa foliacea* (Rh) on a carbonate basis of a coral reef, Mieu Island. Station 3. Bottom near the farms, Mieu and Mot islands, depth 2.5 m, April 26, 2008.

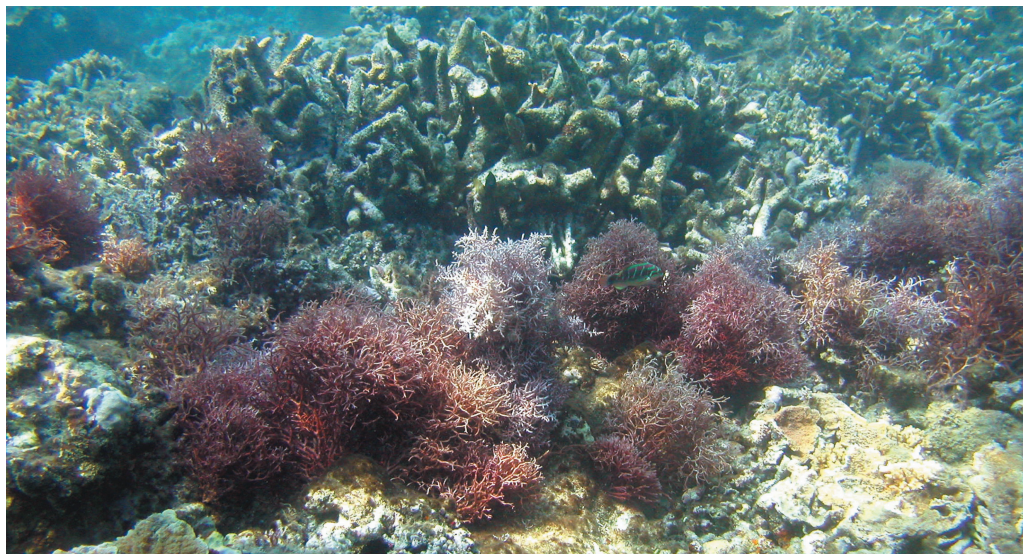


Fig. 16. *Ganonema farinosum* (Rh) on fragments of dead corals. Station 1. Bottom near a farm, Mot Island, depth 2 m, April 9, 2008.

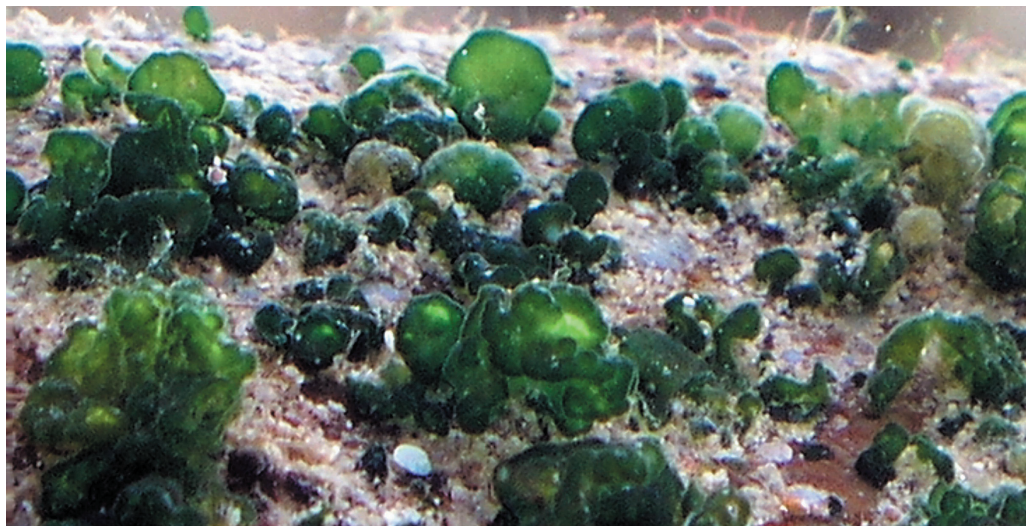


Fig. 17. *Brachytrichia quoyi* (Cy) in the lower intertidal zone, on the rocky bottom. Station 1. Bottom near the farm, Mot Island, April 22, 2006.

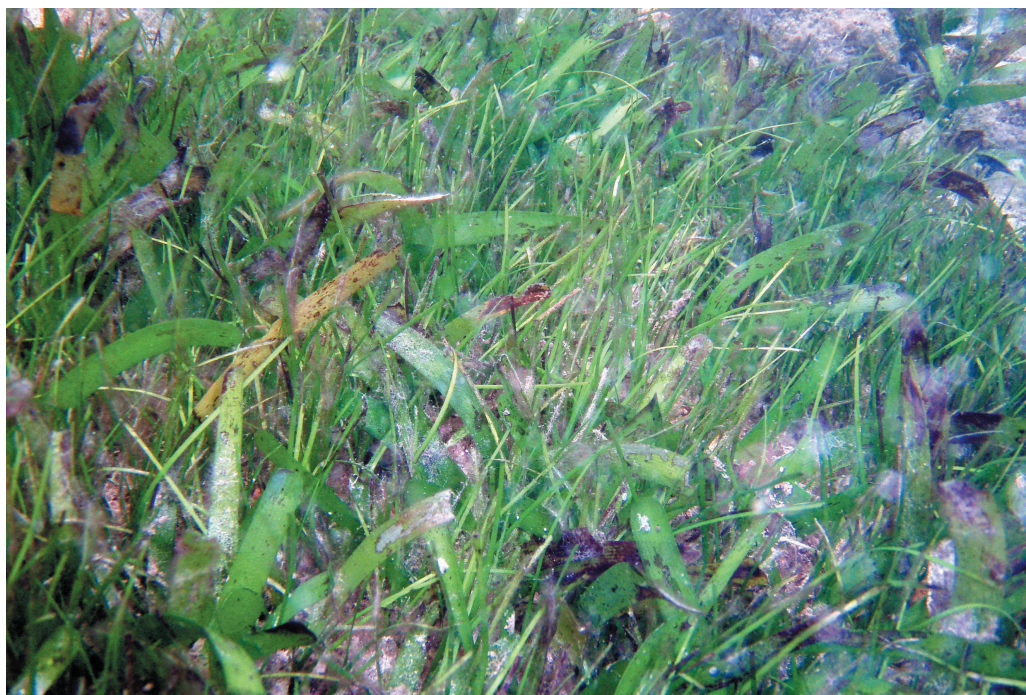


Fig. 18. Association of the sea grasses *Thalassia hemprichii* and *Halodule uninervis* on the sandy bottom among fragments of dead corals. Station 3. Bottom near the farms, Mieu and Mot islands, depth 2 m, April 26, 2008.

Discussion

For the first time a comparative analysis was conducted of the species compositions of plant fouling on the submerged surfaces of lobster farms and of benthic plants near these farms growing in the water enriched with dissolved nitrogen compounds (Titlyanov et al., 2011a). Altogether 158 species of macroalgae (29% of green, 18% of brown, and 53% of red algae), 13 species of cyanobacteria, and 2 species of sea grasses were collected on the farms' structures and on the bottom of Nha Trang Bay. The flora of red, brown, and green fouling macroalgae and benthic macroalgae growing in the upper subtidal of Nha Trang Bay was generally similar to the flora of coral reefs of the Indo-West Pacific region. For example, the flora of the Great Barrier Reef in Australia included 629 species of macroalgae from 3 orders (Rhodophyta, Ochrophyta and Chlorophyta), of which 323 species (51%) were red, 111 species (17%) brown, and 195 species (31%) green (Diaz-Pulido, McCook, 2008). Totally, 419 species of macroalgae were found around Hainan Island (China, South China Sea), including 250 species (59%) of red algae, 63 species (15%) of brown algae, and 106 species (26%) of green algae (Titlyanov et al., 2011b; Titlyanov et al., 2015 (in press); 2015).

On the submerged surfaces of the farms, from the water surface to a depth of 6–7 m (Figs. 19–22), 125 species of macroalgae (29 species of green, 24 brown, and 72 red algae) and 8 species of cyanobacteria were found. In the shallow coastal waters of Mot and Mieu islands on hard and soft bottoms at depths from 0.5 to 2–3 m (Figs. 12–18) 121 species of macroalgae (29 species of green, 27 brown, and 65 red algae), 2 species of sea grasses, and 8 species of blue-green algae were found.

The taxonomic distributions of algae at the farms and on the bottom differed considerably at the levels of both orders and families. Among green algae at the farms members of the following families predominated: Ulvaceae 21% of all green algae, Cladophoraceae 21%, and Caulerpaceae 14%. The number of species belonging to these families was significantly lower on the bottom: respectively, 14%, 10%, and 10%. The collections of benthic algae contained members of the families absent from the aquaculture farms: Polyphysaceae 14% and Halimedaaceae 10%.

The highest numbers of brown algae taxa at the farms were in the following families: Dictyotaceae 35%, Sargassaceae 29%, and Scytosiphonaceae 22%. The relative numbers of taxa in these families were different on the bottom: the numbers of taxa from Sargassaceae and Scytosiphonaceae decreased by 5% and 2%, respectively, and from Sphacelariaceae and Dictyotaceae increased by 3% and 2%, respectively.

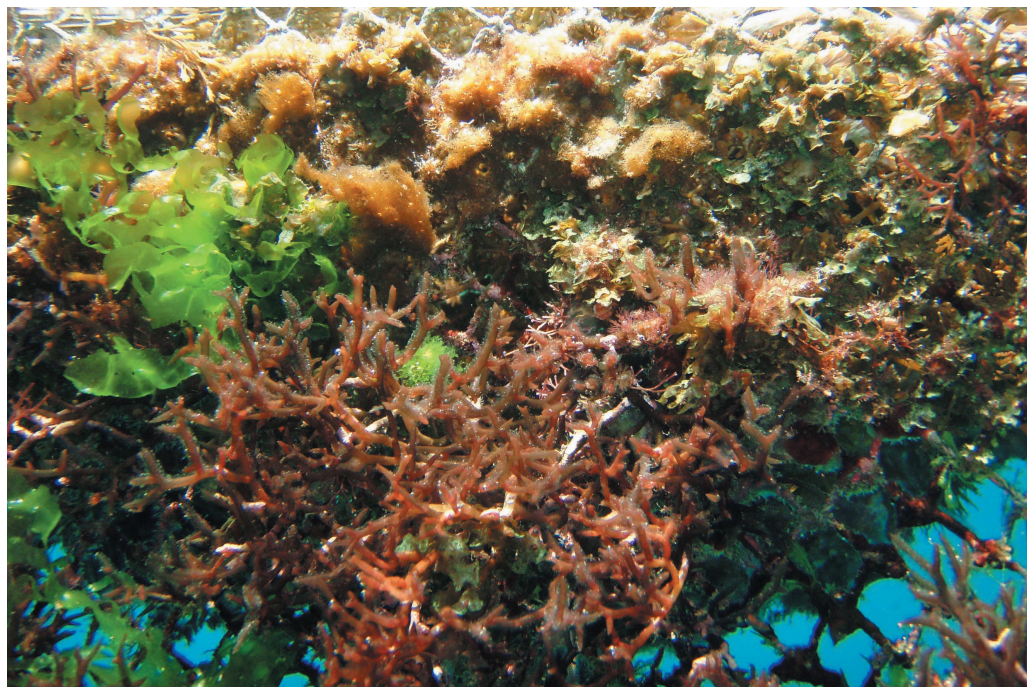


Fig. 19. *Hydropuntia edulis* (Rh) and *Ulva reticulata* (Ch) in the foreground, *Centroceras clavulatum* (Rh) in the background on the inner side of the net cage, from the water surface to a depth of 0.5 m. Station 1. Farm near Mot Island, April 9, 2008.

In the phylum Rhodophyta, containing the highest number of species, members of the following families dominated both at the farms and on the bottom: Corallinaceae 12% and 11%; Ceramiaceae 13% and 11%; Rhodomelaceae 18 and 17%, respectively.

We suggest that the differences in the species diversity and species composition at the farms and on the bottom near these farms were mainly caused by the differences in the quality of the substrate. The lower diversity of benthic algae as compared to algal fouling on the farms' structures, on our opinion, is related to the inaccessibility of hard and soft substrates of the bottom for some algae due to a thick layer of inorganic and organic sediments. Therefore, enrichment of water with dissolved forms of nitrogen and phosphorus (Morand, Briand, 1996; Morand, Merceron, 2004; Lapointe et al., 2005a, b) may not be the main factor controlling plant diversity on damaged or human-impacted coral reefs. It is suggested that the key determinant of plant diversity is the presence and thickness of sediments covering the hard substrate. This suggestion is confirmed by the data on high concentration of dissolved inorganic nitrogen in Nha Trang Bay, both at the farms and



Fig. 20. *Hydropuntia edulis* (Rh) and *Ulva reticulata* (Ch) on the inner side of the net cage, depth 3 m. Station 1. Farm near Mot Island, April 9, 2008.



Fig. 21. *Padina boryana* (Och) and *Jania capillaris* (Rh) on the outer side of the net cage. Station 1. Farm near Mot Island, depth 3 m, April 9, 2008.

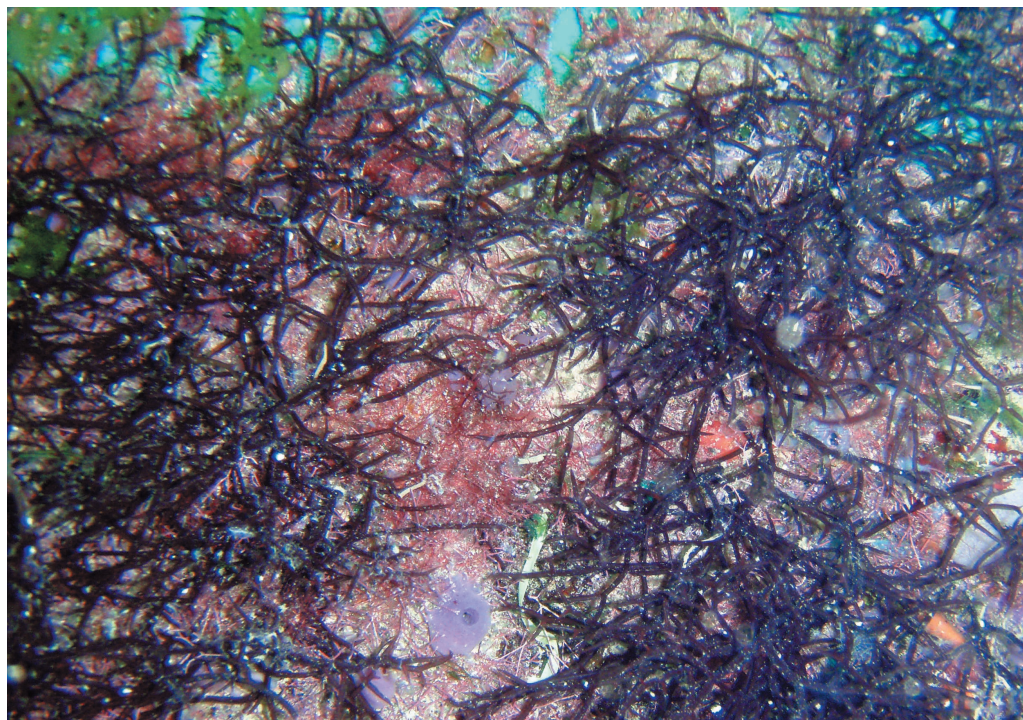


Fig. 22. *Gracilaria coronopifolia* (Rh) on the inner side of the net cage, depth 6 m. Station 1. Farm near Mot Island, April 9, 2008.

in the bottom water layer (Titlyanov et al., 2011a). Moreover, as was shown for Sanya Bay, Hainan Island, and Nha Phu Lagoon (Vietnam), in the waters enriched with nutrients many macrophytes are nitrogen-limited presumably because their thalluses are covered with sediments (Titlyanov et al., 2011a, c).

We also suggest that the difference in the species compositions of fouling algae and benthic macrophytes results from variations in the type and quality of the substrate. For instance, the algae from the family Halimedaceae dominating on the bottom grow only on soft bottoms and thus are not found on the farms' constructions. On the other hand, members of the family Polyphysaceae preferring silted bottom were found only on the bottom.

Eleven new for Vietnam species were found among the fouling algae and benthic plants: *Hydrolithon boreale* (Foslie) Y.M. Chamberlain (on the farms' structures), *Pneophyllum fragile* Kützing (on the farms' structures and on the bottom), *Lomentaria corallicola* Børgesen (on the farms' structures and on the bottom), *Chamaebotrys boergesenii* (Weber-van Bosse) Huisman (on the farms' structures), *Antithamnion antillanum* Børgesen (on the farms' structures), *Martensia fragilis* Harvey

(on the bottom), *Heterosiphonia crispella* (C. Agardh) M.J. Wynne (on the bottom), *Hypoglossum caloglossoides* M.J. Wynne et Kraft (on the farms' structures), *Endosiphonia horrida* (C. Agardh) P.C. Silva (on the bottom), and *Tiffaniella saccorhiza* (Setchell et N.L. Gardner) Doty et Meñez (on the farms' structures) from Rhodophyta; *Dichothrix penicillata* Zanardini ex Bornet et Flahault (on the farms' structures and on the bottom) from Cyanobacteria. All species found in Vietnam for the first time are typical representatives of tropical and subtropical benthic flora of the Indo-West Pacific.

Acknowledgements

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A supplement to the recent Chitonidae (Mollusca: Polyplacophora) of Vietnam

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Abstract: Seven species of the family Chitonidae are presented in this work. Five of them, *Lucilina delecta* Thiele, 1911, *Lucilina* sp. 1, *Lucilina* sp. 2, *Lucilina tenuicostata* sp. nov. and *Onithochiton helenae vietnamensis* subsp. nov., are new for the waters of Vietnam, and the last two are new for science. Data on the fauna of chitonids, the most abundant group of chitons (22 species) in the waters of Vietnam, are summarized, and the significance of pectination of insertion plates in the genera *Tonicia*, *Lucilina* and *Onithochiton* is discussed.

Key words: Chitonidae, chitons, new species, Vietnam, South China Sea.

Vietnamese chitons of the family Chitonidae were first mentioned by Leloup (1952) who reported seven species (*Chiton hululensis* (Smith, 1903), *Ch. pulcherimus* Sowerby, 1841, *Ch. (Rhyssoplax) venusta* (Hull, 1923), *Acanthopleura spinosa* (Bruguière, 1792), *Liolophura japonica* (Bruguière, 1792), *Tonicia confossa* (Gould, 1846) (= *Lucilina lamellosa* (Quoy et Gaimard, 1835)), and *Tonicia sowerbyi* (Nierstrasz, 1905)). Dawydoff (1952) listed nine species, the six of them being the same as those reported by Leloup, but the remaining three absent from the fauna of Vietnam. Nguyen et al. (1997) and Nguyen (2001) confirmed the finding of *L. japonica* in the waters of Vietnam. Strack (2003) reported 18 species belonging to the family Chitonidae in his check list of Vietnamese chitons. Eleven of them (the seven above mentioned species and the four new ones for Vietnam: *Chiton burmanus* Carpenter in Pilsbry, 1893, *Ch. cf. speciosus* Nierstrasz, 1905, *Acanthopleura loochooana* (Broderip et Sowerby, 1829), and *Onithochiton* sp. (= *O. stracki* Sirenko, 2012)) have been confirmed to inhabit Vietnamese waters. According to this author, the status of seven species is unknown or their records need verification. Up to now, they have not yet been found and are probably absent from Vietnamese waters. Since the first work of Sirenko (2012) on the chitons of Vietnam, 16 species of the family have been listed. The investigations were carried out in 2011, 2012, 2013, and 2014 all along the coast of Vietnam from the Gulf of Siam (Gulf of Thailand) to the Gulf of Tonkin and resulted in five new species for Vietnam.

Abbreviations

BL – body length

BMNH – The Natural History Museum (formerly British Museum (Natural History)), London, UK

IEERAS – A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russia

Is – island

Spm(s) – specimen(s)

ZIM – Zoologisches Museum und Zoologisches Institut der Universität, Berlin, Germany

ZISP – Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia

Material and methods

The studied specimens were collected by the author during several field trips to Vietnam in 2010, 2011, 2012, 2013, and 2014. The author took part in the expeditions of Russian-Vietnamese Tropical Centre. The materials were collected by using snorkel and SCUBA equipment. During the expeditions a new method of chitons collecting described in Sirenko (2012) was used.

One specimen of each species and separate valves selected from sand were prepared for examination by scanning electron microscopy (SEM). The specimens were boiled in 7% KOH during 10–15 min; then they were boiled twice in fresh water; then several valves (usually valves I, IV, V, and VIII), a half of radula and a portion of girdle were chosen for examination by SEM. The rest of radula and girdle were dried and put in Canada balsam for examination under a light microscope.

Taxonomy

Family **Chitonidae** Rafinesque, 1815
Subfamily **Chitoninae** Rafinesque, 1815
Genus ***Rhyssoplax*** Thiele, 1893

Type species. *Chiton janeirensis* Gray, 1828, sensu Thiele, 1893 (= *Chiton affinis* Issel, 1869), by subsequent designation.

***Rhyssoplax cf. maldivensis* (E.A. Smith, 1903)**

Figs. 1–3, 13B, C

Ischnochiton maldivensis E.A. Smith, 1903, p. 596, pl. 36, figs. 7–10.

Rhyssoplax maldivensis (E.A. Smith, 1903): Kaas et al., 2006, p. 170, fig. 63, maps 11, 32 (synonymy and bibliography); Dell Angelo et al., 2010, p. 13, fig. 4G–I; Sirenko, 2012, p. 78, fig. 20A–G.

Type. BMNH 1903.9.17.26.

Type locality. Maldive Archipelago, Felidu Atoll, 2–64 m.

Material examined. Vietnam, Shon Cha, 16°12.649' N, 108°11.633' E, 10 m, rocks on shells of bivalves; 1 spm, BL 13.5 mm, 20.04.2013, leg. B.I. Sirenko.

Distribution. The Red Sea, the Gulf of Aden, Maldive Archipelago, Vietnam.

Remarks. The first find of this species in the waters of Vietnam was reported in Sirenko (2012). Several valves of the species were found in Nha Trang Bay, in sand, at a 16–23 m depth. In 2013, one alive specimen (BL 13.5 mm) was found near Da Nang. It had 29 gills per side arranged from valve II to valve VIII and a radula 4.4 mm long with 40 transverse rows of mature teeth.

The specimen differs from the Maldive's specimens by the narrower jugal sinus; shorter antemucronal area; quite smooth (without growth lines and any ribs) lateral areas in the intermediate valves and postmucronal areas in the tail valve, and the arrangement and length of longitudinal grooves in the central areas. The find of this species in Vietnam considerably widened its distributional range.

Subfamily **Toniciinae** Pilsbry, 1893

Genus ***Lucilina*** Dall, 1882

Type species. *Chiton confissus* Gould, 1846 (= *Chiton lamellosus* Quoy et Gaimard, 1835) by subsequent designation by Pilsbry, 1893.

***Lucilina dilecta* Thiele, 1911**

Fig. 4

Lucilina dilecta Thiele, 1911, p. 397, pl. 6, figs 1, 2; Iredale, Hull, 1926, p. 269, pl. 38, fig. 15.

?*Tonicia carpenteri* Angas, 1867, p. 116, pl. 13, fig. 30.

Tonicia (*Lucilina*) *dilecta* (Thiele, 1911): Ashby, 1928, p. 173; Kaas et al., 2006, p. 344, fig. 144, map 53 (synonymy and bibliography).

Type. ZIM.

Type locality. Western Australia, Shark Bay, 0–12.5 m.

Material examined. Vietnam, Nha Trang Bay, Nok Is., 12°11'34.1" N, 109°20'19.2" E, 12–22 m, on old shells and corals, 1 intermediate valve, length 3.2 mm, breadth 5.8 mm, 08.05.2010, leg. B.I. Sirenko.

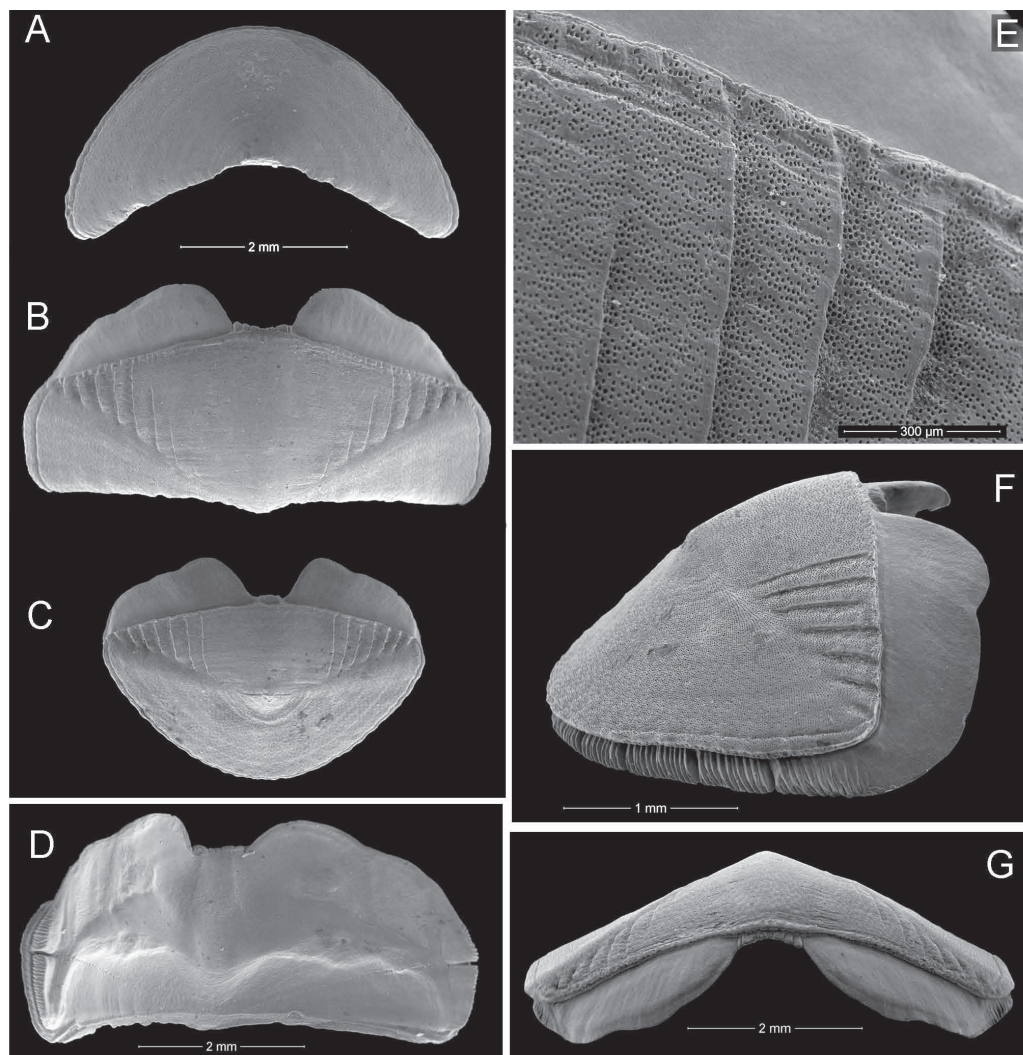


Fig. 1. *Rhyssoplax* cf. *maldivensis*. BL 13.5 mm, Vietnam, Shon Cha Is., 10 m, on bivalve shells; **A** – valve I, dorsal view; **B** – valve V, dorsal view, **C** – valve VIII dorsal view; **D** – valve IV, ventral view; **E** – valve V, detail of tegmentum in central area; **F** – valve VIII, lateral view; **G** – valve V, rostral view.

Distribution. Western Australia, Shark, Broome and Karatha bays and south Vietnam.

Remarks. The intermediate valve of the Vietnam specimen is similar to that of *Lucilina carpenteri* (Angas, 1867) by an unusual waved sculpture of the tegmentum. *L. carpenteri* may be a synonym of *L. dilecta* (Kaas et al., 2006, p. 342). It is necessary to collect and study whole specimens in order to clarify the species status of the Vietnamese find.

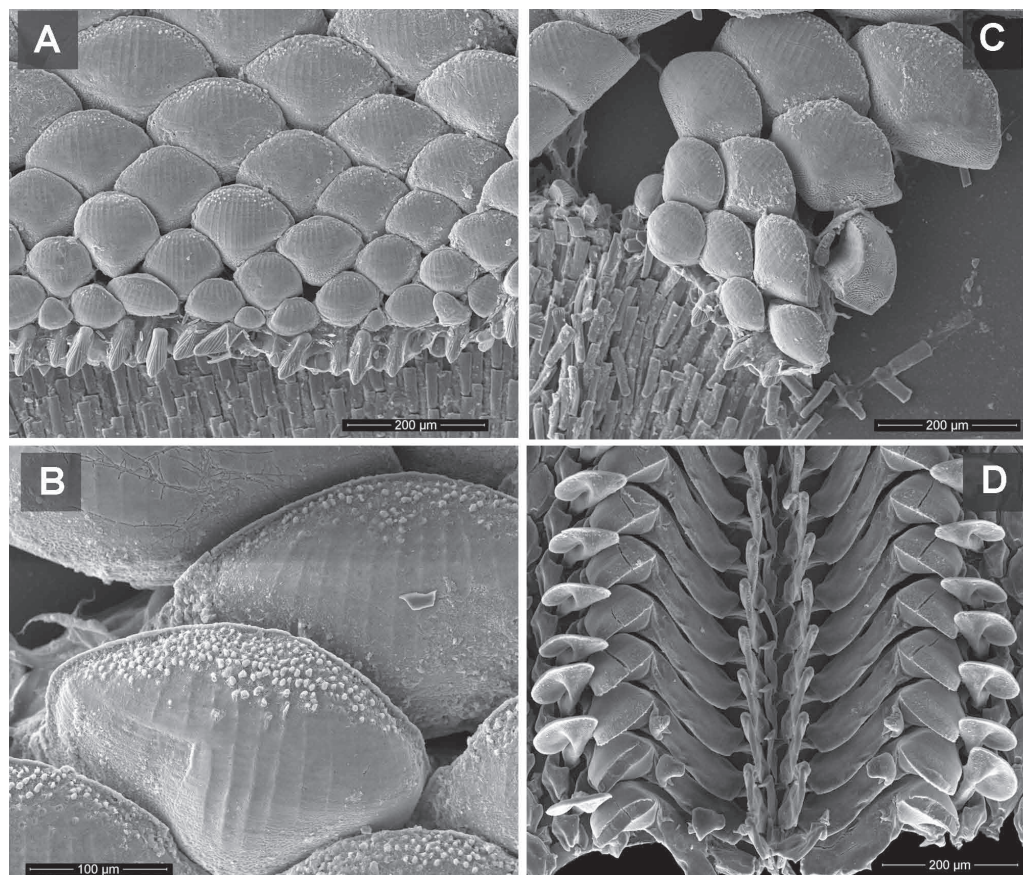


Fig. 2. *Rhyssoplax* cf. *maldivensis*. BL 13.5 mm, Vietnam, Shon Cha Is., 10 m, on bivalve shells; A, C – dorsal scales, marginal spicules and ventral scales; B – dorsal scales; D – radula.

***Lucilina* cf. *sowerbyi* (Nierstrasz, 1905)**

Figs. 5, 6, 13E, F

Tonicia sowerbyi Nierstrasz, 1905, p. 92, figs. 33, 170–173; Nierstrasz, 1906, p. 146.

Tonicia (*Lucilina*) *sowerbyi* Nierstrasz, 1905: Leloup, 1952, p. 64; Leloup, 1973, p. 1, figs. 1, 2; Kaas et al., 2006, p. 329, fig. 136, map 19.

Lucilina sowerbyi (Nierstrasz, 1905): Sirenko, 2012, p. 80, fig. 7D.

Type. BMNH.

Type locality. Lombok, south of Saleyer, Poeloe Kabala-Doea, Banda, NE Timor, Indonesia, 0–22 m.

Material examined. South Vietnam, Nha Trang Bay, Mun Is., 12°10' N, 109°18' E, 6–7 m, intermediate valve, 13.15.2009, leg. B.I. Sirenko; Cau Is., 11°13.508' N, 108°50.142' E, 12–17 m, SCUBA, on bivalve shells, 8 spms,

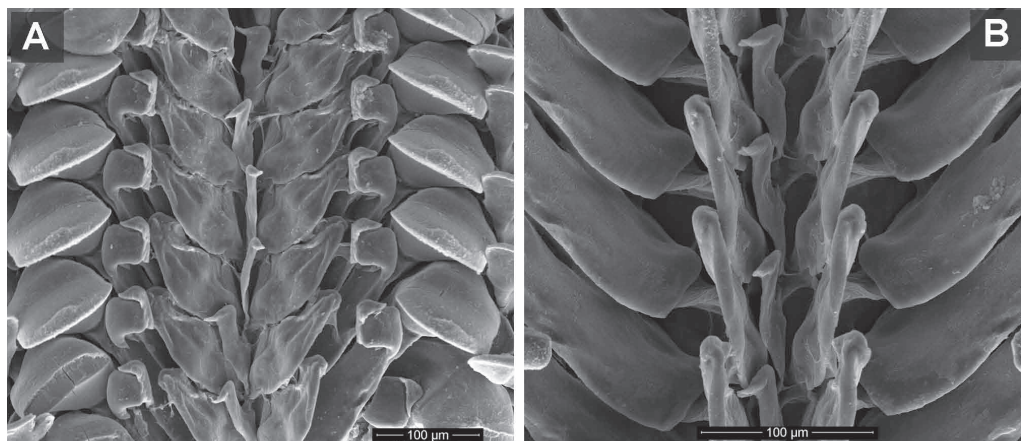


Fig. 3. *Rhyssoplax* cf. *maldivensis*. BL 13.5 mm, Vietnam, Shon Cha Is., 10 m, on bivalve shells; **A, B** – central portion of radula.

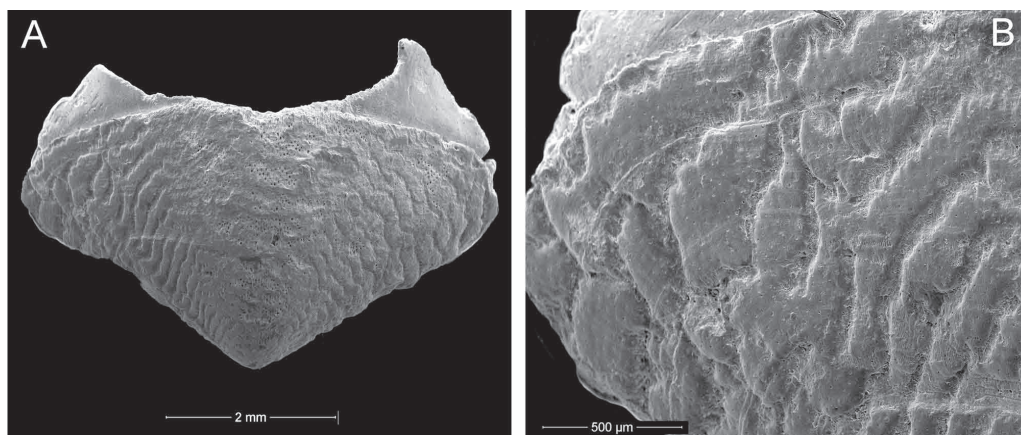


Fig. 4. *Lucilina dilecta*. intermediate valve 3.2x5.8 mm, Vietnam, Nha Trang Bay, Nok Is., 12–22 m, on old shells and corals; **A** – intermediate valve dorsal view; **B** – detail of tegmentum in central area.

BL 3–11 mm, 06.05.2011, leg. B.I. Sirenko; Nha Trang Bay, Tre Is., 12°12.098' N, 109°13.178' E, 12–22 m, SCUBA, on shells and stones, 2 spms, BL 6–7 mm, 06.06.2012, leg. B.I. Sirenko; Cau Is., 11°13.727' N, 108°50.104' E, 10–13 m, SCUBA, on old shells and on *Maleus maleus* L., 1758, 1 spm, BL 4 mm, 11.05.2013, leg. B.I. Sirenko; 11°13.322' N, 108°49.866' E, 15–18 m, SCUBA, on old shells, 5 spms, BL 2–6 mm, 14.05.2013, leg. B.I. Sirenko; 11°13.756' N, 108°50.159' E, 15–17 m, SCUBA, on old shells, 5 spms, BL 3–6 mm, 14.05.2013, leg. B.I. Sirenko; 11°13.573' N, 108°50.044' E, 12–17 m, SCUBA, on old shells, 5 spms, BL 2–8 mm,

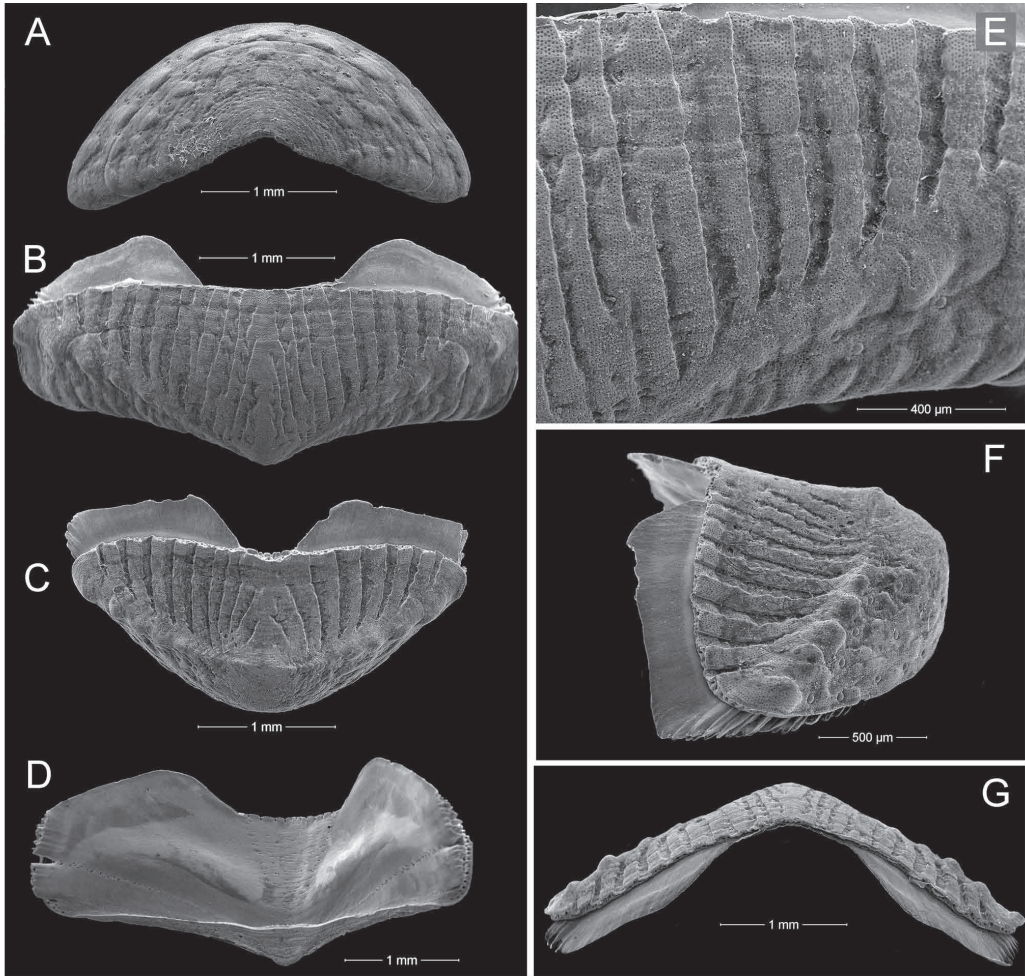


Fig. 5. *Lucilina* cf. *sowwerbyi*. BL 9.0 mm, Vietnam, Cau Is., 12–16 m on shells; **A** – valve I, dorsal view; **B** – valve V, dorsal view; **C** – valve VIII, dorsal view; **D** – valve IV, ventral view; **E** – valve V, detail of tegmentum in central and lateral areas; **F** – valve VIII, lateral view; **G** – valve V, rostral view.

15.05.2013, leg. B.I. Sirenko; 11°13.937' N, 108°50.091' E, 12–15 m, SCUBA, on old shells, 4 spms, BL 4–7 mm, 15.05.2013, leg. B.I. Sirenko; Cau Is., 11°13'34.5" N, 108°50'02.7" E, 6–10 m, SCUBA, on old shells, 4 spms, BL 3–7 mm, 11.05.2014, leg. S. Grebelny; 11°13'44.5" N, 108°49'17.7" E, 4–6 m, SCUBA, on old shells, 1 spm, BL 8 mm, 11.05.2014, leg. S. Grebelny; Nha Trang Bay, Nok Is., 12°11'34.1" N, 109°20'19.2" E, 4–6 m, SCUBA, on old shells, 1 spm, BL 4 mm, 21.05.2014, leg. B.I. Sirenko.

Distribution. Indonesia, New Caledonia, south Vietnam, 6–22 m.

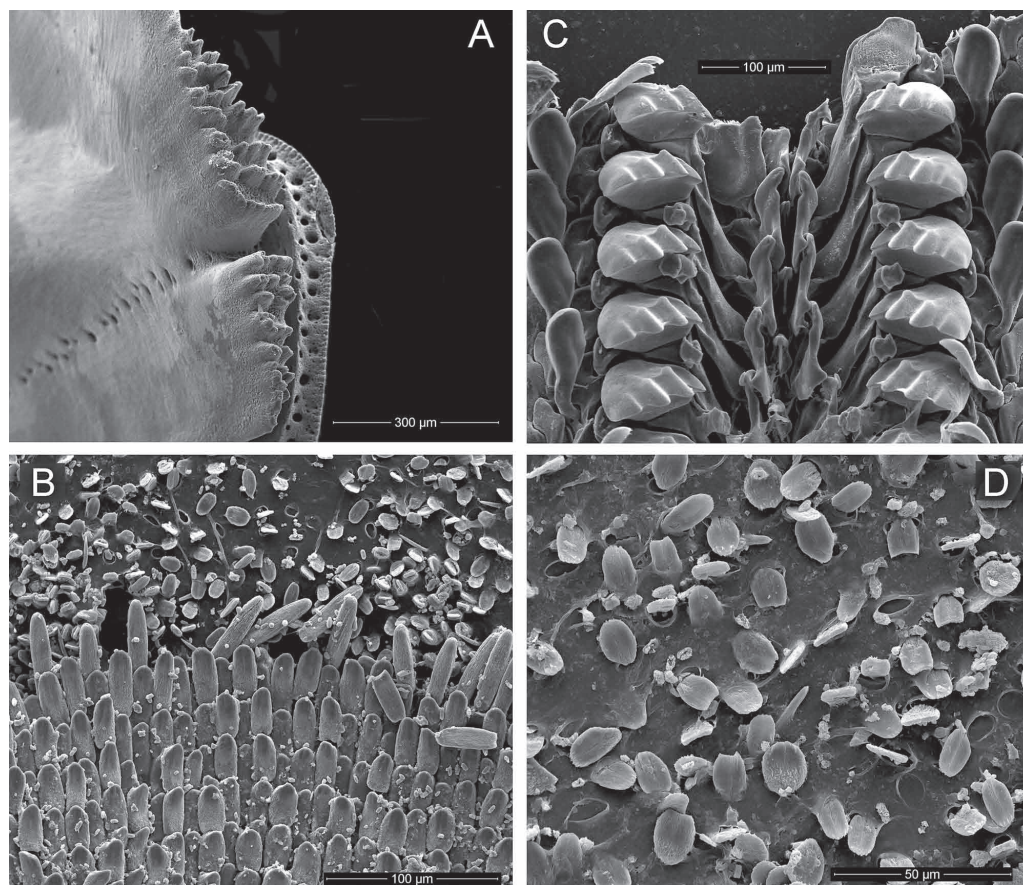


Fig. 6. *Lucilina* cf. *sowerbyi*. BL 9.0 mm, Vietnam, Cau Is., 12–16 m, on shells; **A** – valve IV, slit ray and pectinated insertion plate and apophyses; **B** – dorsal, marginal and ventral scales; **C** – radula; **D** – dorsal scales.

Remarks. The studied specimen (Cau Is., 11°13.508' N, 108°50.142' E, 12–17 m, SCUBA, on bivalve shells, BL 9 mm, 06.05.2011) has 18 gills per side, arranged from valve II to valve VII, radula 2.6 mm long with 31 transverse rows of mature teeth. Slit formula 8/1/12. The Vietnamese specimens are similar to *Lucilina fortilirata* (Reeve, 1847) (Australia), *L. variegata* (Nierstrasz, 1905) (Indonesia) and *L. tydemani* (Nierstrasz, 1905) (Indonesia). Our specimens differ from *L. fortilirata* in having round nodules in the head valve (angular in *L. fortilirata*), and the jugal area sculptured by converging grooves (smooth in *L. fortilirata*); from *L. variegata* by round nodules in the head valve (radiating rows of roundish elongate or V-shaped pustules in *L. variegata*), the tail valve as wide as the head valve (the tail valve wider than the head valve in *L. variegata*), the jugal area sculptured by converging grooves

(smooth in *L. variegata*), and the dorsal spicules twice smaller than those of *L. variegata*. The Vietnamese specimens differ from *L. tydemani* in having the jugal area sculptured by converging grooves (very finely punctate in *L. tydemani*), no dentation of the sutural margin in the intermediate valves (*L. tydemani* has dentation). The Vietnamese specimens differ from *L. sowerbyi* in having smaller dorsal spicules (17x12 μm vs. 38x10 μm).

***Lucilina* sp. 1**

Fig. 7

Material examined. South Vietnam, Conson Archipelago, Hon Ba Is., 08°37.890' N, 106°33.378' E, 12–15 m, SCUBA, on old corals, 1 tail valve, (width 4.1 mm), 13.04.2011, leg. B.I. Sirenko.

Remarks. The color of the tegmentum of the tail valve found in Vietnam is light brown with a white jugal area blotched with brown spots of different sizes. The sculpture of the tegmentum in the antemucronal area consists of 14 longitudinal narrow grooves, only six of which, near the outer margin, reach the front margin, those towards the mucro being progressively shorter, the jugal area wide and smooth. The postmucronal area is with radial subgranulated ribs, the shell eyes arranged in grooves between the radial ribs. The tail valve from Vietnam is similar to those of *L. floccata* (Sowerby, 1842) by radial subgranulated ribs in the postmucronal area, but differs from it in having a wide and smooth jugal area. The tail valve from Vietnam is also similar to *L. polyomma* Bergenhayn, 1932 (both have narrow ribs on the pleural areas), but differs from the latter in having ocelli distributed between radial subgranulated ribs in the postmucronal area (ocelli sparsely and randomly distributed in *L. polyomma*).

***Lucilina* sp. 2**

Fig. 8

Material examined. South Vietnam, Conson Archipelago, Hon Ba Is., 08°38' N, 106°35.5' E, 6–9 m, SCUBA, sand, 1 intermediate valve (width 6.5 mm), 15.04.2010, leg. B.I. Sirenko.

Remarks. There are several elongated pits near the narrow jugal area in the intermediate valve found in Vietnam. The tegmentum of the pleural areas is sculptured with 15 close-set longitudinal, granulose riblets similar to those of *L. polyomma* and *L. floccata*. The intermediate valve from Vietnam differs from those of *L. polyomma* in having the pleural area with longitudinal close-set granulose riblets of about the same width (fine and close-set riblets near the jugum, getting stronger and wider towards the side in *L. polyomma*), the lateral areas without radiating

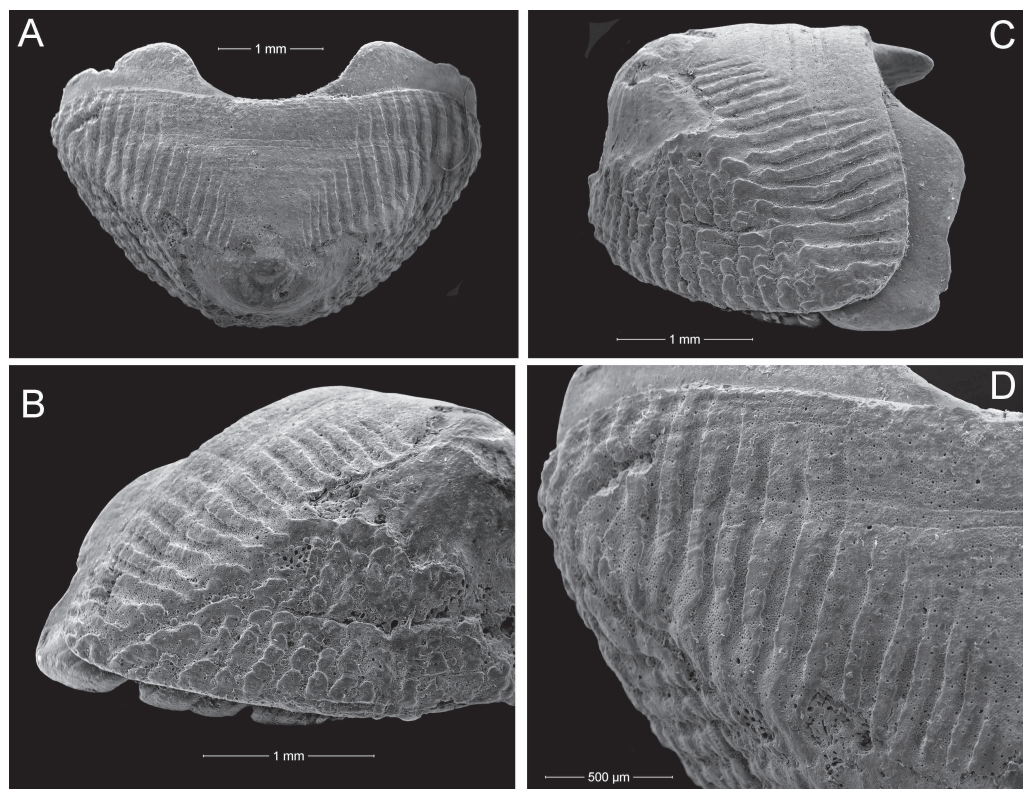


Fig. 7. *Lucilina* sp. 1. Tail valve, width 4.1 mm, Vietnam, Conson Archipelago, Hon Ba Is., 12–15 m, on old corals. **A** – dorsal view; **B** – lateral view; **C** – detail of tegmentum in antemucronal area; **D** – detail of tegmentum of postmucronal area.

riblets (with radiating riblets in *L. polyomma*). The intermediate valve from Vietnam differs from those of *L. floccata* by having the lateral areas without radiating rows of granules (with radiating rows of small granules in *L. floccata*) and the pleural area with several elongated pits near the jugal area (without pits in *L. floccata*)

***Lucilina tenuicostata* Sirenko sp. nov.**

Figs. 9, 10, 13D, G

Type. The holotype (ZISP 2243) now disarticulated, consisting of mounts of shell, armature of girdle and radula; and 1 paratype (ZISP 2244).

Type locality. Vietnam, Gulf of Tonkin, Cat Ba Is., 20°47.090' N, 107°06.103' E, 1–1.5 m, SCUBA, on old shells.

Etymology. The name is Latin for narrow ribs in the central areas of the intermediate valves.

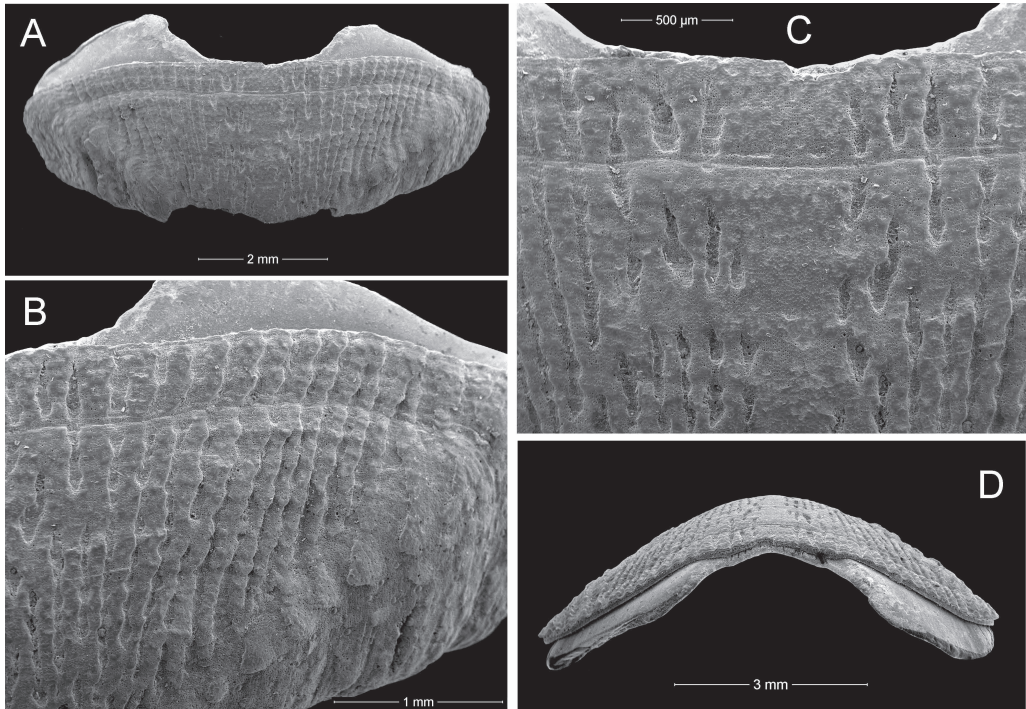


Fig. 8. *Lucilina* sp. 2. Intermediate valve, width 6.5 mm, Vietnam, Conson Archipelago, Hon Ba Is., 8–9 m, in sand; **A** – dorsal view; **B** – rostral view; **C** – detail of tegmentum in jugal area; **D** – detail of tegmentum in pleural and lateral area.

Material examined. Vietnam, Gulf of Tonkin, Cat Ba Is., 20°46.042' N, 107°05.800' E, 8 m, SCUBA, on old shells, 4 spms, BL 6–7 mm, 30.04.2012, leg. B.I. Sirenko; 20°47.090' N, 107°06.103' E, intertidal, on oysters and barnacles, 1 spm, BL 6 mm, 01.05.2012, leg. B.I. Sirenko; 20°47.090' N, 107°06.103' E, 1–1.5 m, SCUBA, on old shells, holotype, BL 9 mm and 1 paratype, BL 8.5 mm, 01.05.2012, leg. B. Sirenko; 20°47.090' N, 107°06.103' E, 1–1.5 m, SCUBA, on old shells, holotype, BL 9 mm and 1 paratype, BL 8.5 mm, 01.05.2012, leg. B.I. Sirenko; 20°47.090' N, 107°06.103' E, 3–6 m, SCUBA, on shells of *Pinna* spp. and *Isognomon* sp., 2 spms, BL 8–10 mm, 01.05.2012, leg. B. Sirenko; 20°44.497' N, 107°04.098' E, 5–6 m, SCUBA, on shells of *Pinna* spp. and *Isognomon* sp., 4 spms, BL 8–10 mm, 01.05.2012, leg. B.I. Sirenko; 20°47.379' N, 107°07.216' E, 2–4 m, SCUBA, on shells of *Isognomon* sp., 2 spms, BL 8–12 mm, 03.05.2012, leg. B.I. Sirenko; 20°46.310' N, 107°07.700' E, 3–4 m, SCUBA, on shells of *Pinna* spp. and *Isognomon* sp., 3 spms, BL 4–8.5 mm, 04.05.2012, leg. B.I. Sirenko; 20°45.957' N, 107°07.722' E, 3–4 m, SCUBA, on bivalve shells, 1 spm, BL 9 mm, 06.05.2012, leg.

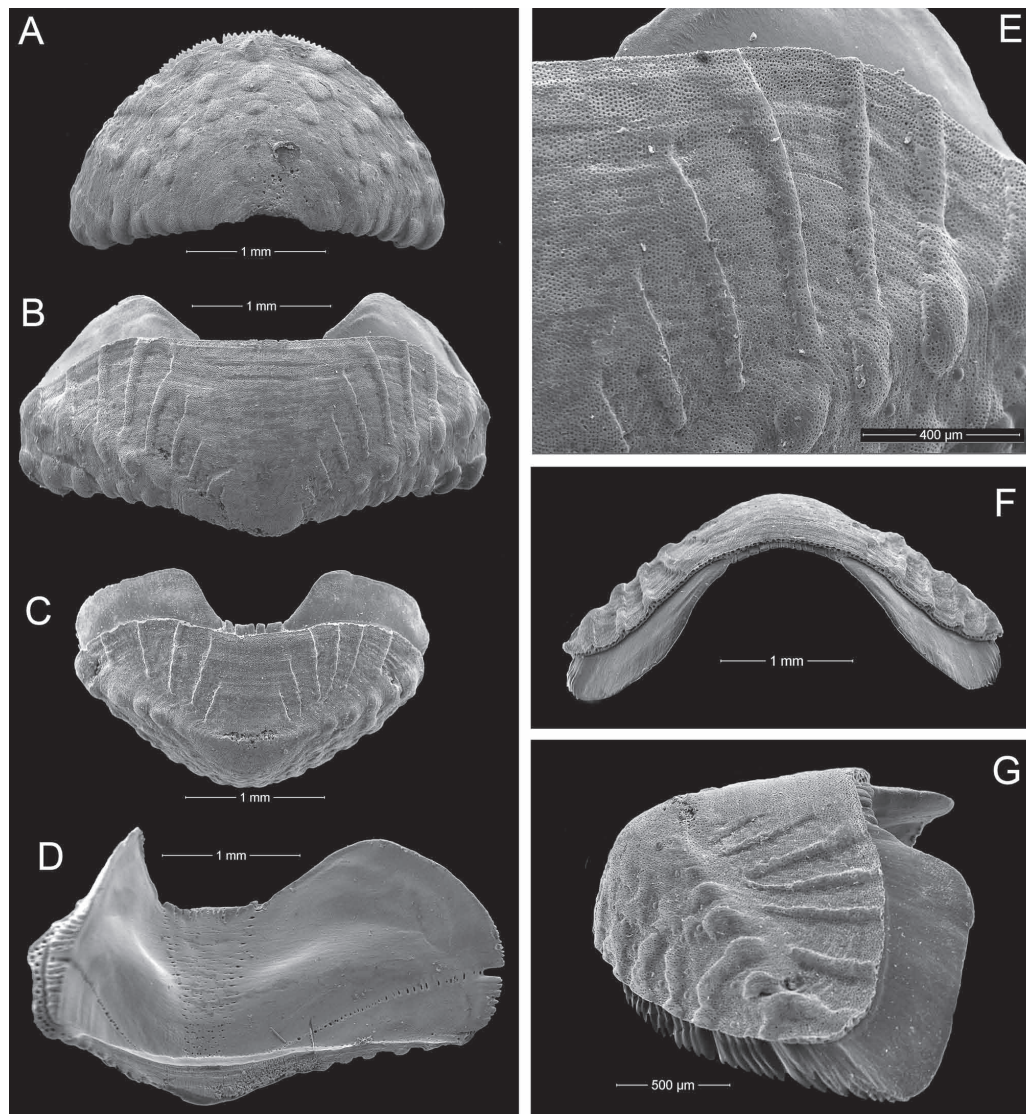


Fig. 9. *Lucilina tenuicostata* Sirenko sp. nov., **holotype**, BL 9.0 mm Vietnam, Gulf of Tonkin, Cat Ba Is., 1–1.5 m, on bivalve shells; **A** – valve I, dorsal view; **B** – valve V, dorsal view, **C** – valve VIII dorsal view; **D** – valve IV, ventral view; **E** – valve V, detail of tegmentum in pleural area; **F** – valve V, rostral view; **G** – valve VIII, lateral view.

B.I. Sirenko; 20°43.675' N, 107°03.373' E, intertidal, on stones, 2 spms, BL 9–12 mm, 08.05.2012, leg. B.I. Sirenko; near Da Nang, 16°07'57.8" N, 108°18'35.7" E, 4 m, SCUBA, on barnacles, 1 spm, BL 5 mm, 17.05.2012, leg. O. Savinkin; Van Don, 21°01'50.2" N, 107°33'26.3" E, 3 m, SCUBA, on stones, 2 spms, BL 4–7 mm,

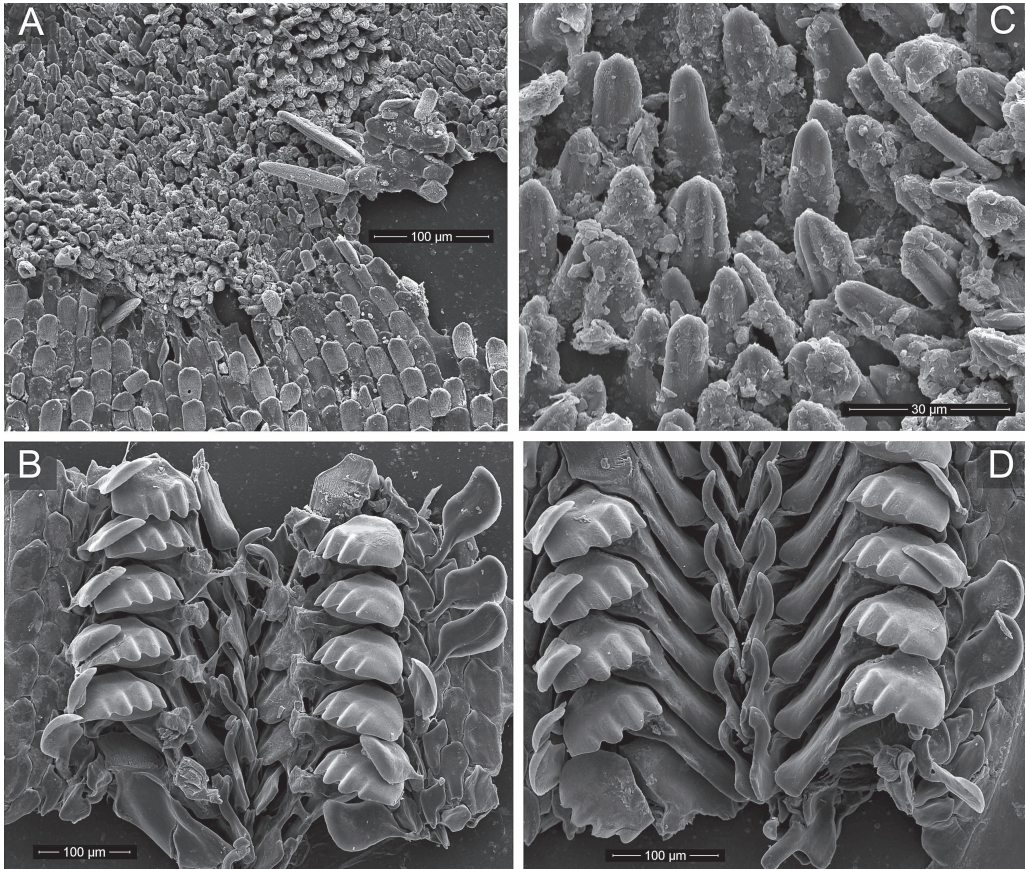


Fig. 10. *Lucilina tenuicostata* Sirenko sp. nov., **holotype**, BL 9.0 mm Vietnam, Gulf of Tonkin, Cat Ba Is., 1–1.5 m, on bivalve shells; **A** – dorsal, marginal and ventral spicules and needles; **B** – dorsal scales and needles; **C, D** – radula.

03.04.2014, leg. B.I. Sirenko; Son Duong, 18°06'23.6" N, 106°27'35.7" E, 1–3 m, SCUBA, on barnacles, 1 spm, BL 7 mm, 21.04.2014, leg. S. Grebelny; Con Co Is., 17°09'20.8" N, 107°20'55.8" E, 1.5–2 m, SCUBA, on stones and old corals, 1 spm, BL 5.8 mm, 26.04.2014, leg. S. Grebelny.

Distribution. Vietnam, from Con Co Is., 17°09' N to Van Don, 21°02' N, intertidal – 5 m.

Diagnosis. Animal of small size, shell rather low and rounded. Tegmentum of head valve with rounded pustules arranged in radial rows. Pleural areas of intermediate valves with longitudinal narrow ribs, several inner ribs forwardly converging to wide smooth jugal area. Interspace usually twice wider than rib. Dorsal scales with four ribs. Ventral with about 10 weak ribs in middle portion and smooth near outer margin.

Description. Animal of small size, holotype, BL 9.0 mm, elongate oval, moderately elevated (dorsal elevation 0.35), shell rounded, side slopes straight, valves somewhat beaked. Tegmentum yellowish, blotched with light brown, olive and white; valve II and lateral areas of valve V brown. Girdle colored in predominant tegmental color, irregularly blotched with white.

Head valve semicircular, front slope slightly convex, tegmentum sculptured with rounded pustules arranged in 10 radial rows, pustules serrate sutural margin, interstices each with a row of minute round black ocelli. Intermediate valves with front margin straight in a wide central part, splayed laterally, side margins rounded, hind margin almost straight at both sides of small rounded apex. Lateral areas not raised, clearly marked by sharply elevated diagonal ridge, bearing up to 7 pustules, posteriorly a radiating row of transverse pustules dentates sutural margin, ocelli on anterior half of area; wide jugal area smooth; pleural areas with 7–8 very narrow longitudinal ribs, several inner ribs forwardly converging to jugal area. Tail valve slightly narrower than head valve, the length somewhat less than half the width, front margin weakly concave, hind margin angular, mucro posterior, hind slope about vertical, antemucronal area straight, sculptured like central areas, postmucronal area with long pustules irregularly distributed.

Articulamentum white with light brown in middle portion, apophyses triangular with rounded top, jugal sinus straight, about 1/5 of the valve's width, provided with a very short, finely denticulated plate. Slit formula 8/1/12, slit rays well indicated, teeth short, finely grooved on the upper side, sharply pectinated at outer edge, eaves short, solid.

Girdle about 1.1 mm wide near valve V, dorsally covered with closely set pointed scales, 23x11 μm , ornamented dorsally with four ribs, interspersed with slender, cylindrical, somewhat curved spines up to 38x3 μm . Marginal spicules 51–76x12–15 μm , flattened, with 4 ribs on dorsal side. Ventral scales rectangular, 24x 21 μm , with about 10 weak ribs on dorsal side, those near margin longer, 34x12 μm , and smooth.

Radula of the holotype 3.1 mm long, with 39 transverse rows of mature teeth, central tooth short, somewhat pinched in the middle, major lateral one with a tetracuspid blade with short denticles.

The holotype with 21 gills on both sides, extending from valve III to valve VII.

Remarks. *L. tenuicostata* is superficially similar to *L. carnosa* (Kaas, 1979) and *L. tilbrooki* Milne, 1958 by the presence of longitudinal ribs on the pleural areas of the intermediate valves. New species differs from both the above mentioned species in having radial rows of rounded pustules on the head valve (*vs.* V-shaped nodules) and narrow longitudinal innermost ribs forwardly converging on both

sides of the wide smooth jugal area (*vs.* innermost ribs not forwardly converging in *L. carnosa* and *L. tilbrookii*). *L. tenuicostata* differs from *L. tydemani* (Niestrasz, 1905) in having 10 radiating rows of large pustules on the head valve (12–16 radiating rows of small pustules with some shorter secondary rows in between in *L. tydemani*), the wide and smooth jugal area (jugal area narrow and very finely punctate in *L. tydemani*), and the dorsal scales with 4 ribs (cupped, stout, longitudinally striate, blunt-topped calcareous spicules in *L. tydemani*).

Genus *Onithochiton* Gray, 1847

Type species. *Chiton undatus* Quoy et Gaimard, 1835, non Wood, 1828 (= *Onithochiton neglectus* de Rochebrune, 1881) by subsequent designation by Gray, 1847.

Onithochiton helenae vietnamensis Sirenko subsp. nov.

Figs. 11, 12, 13A

Type. The holotype (ZISP 2245) now disarticulated, consisting of mounts of shell, armature of girdle and radula, and 3 paratypes (ZISP 2246).

Type locality. Vietnam, near Da Nang, 16°11.802' N, 108°10.593' E, rocky intertidal, on barnacles.

Etymology. Named after Vietnam.

Material examined. Vietnam, near Da Nang, 16°11.802' N, 108°10.593' E, rocky intertidal, on barnacles, holotype, BL 13.0 mm, and 3 paratypes, BL 8–11 mm, 16.05.2012, leg. O. Savinkin.

Distribution. Known only from the type locality.

Diagnosis. Animal of small size, shell rounded. Tail valve much narrower than head valve. Tegmentum of head valve, lateral area of intermediate valves, and postmucronal area of tail valve smooth, without pustules. Pleural areas with 8–9 very short and deep longitudinal grooves along diagonal line. Insertion plates of head and intermediate valves very short, faintly pectinated. Dorsal spicules blunt-topped, distally sculptured, with 5 sharp riblets. Ventral scales smooth. Major lateral tooth bearing a cusp with 4 denticles.

Description. The holotype 13.0x6.6 mm, elongated, oval, shell rather flat (dorsal elevation 0.35), rounded, slightly beaked. Color of tegmentum yellowish, but valves II, III, VI, VII, and VIII blotched with brown and olive. Girdle brownish, with irregular white bands and spots.

Head valve semicircular, hind margin broadly V-shaped, tegmentum smooth with 13 very weak flattened radial rows, ocelli in radiating rows in between. Intermediate valves broadly rectangular, front margin straight or slightly concave, hind

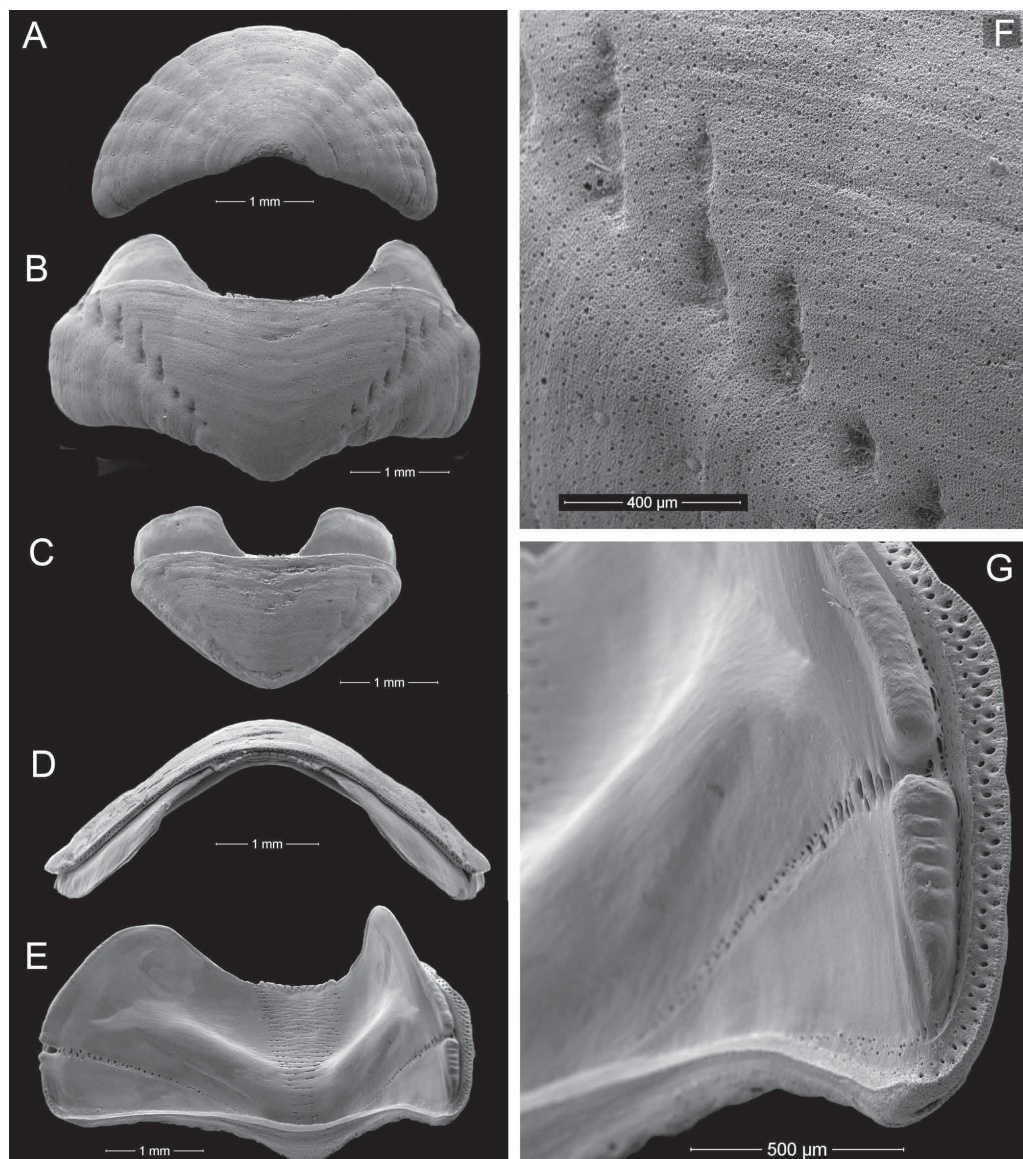


Fig. 11. *Onithochiton belenae vietnamensis* Sirenko subsp. nov., **holotype**, BL 13.0 mm, Vietnam, near Da Nang, rocky intertidal, on barnacles; **A** – valve I, dorsal view; **B** – valve V, dorsal view; **C** – valve VIII dorsal view; **D** – valve V, rostral view; **E** – valve IV, ventral view; **F** – valve V, detail of tegmentum in pleural area; **G** – valve IV, ventral view, insertion plate, hind portion of apophyses, eaves and slit rays.

margin bluntly angular, apex obtusely indicated. Lateral areas raised, smooth; central area smooth, except for 8 short longitudinal grooves on both sides, arranged along diagonal line. Tail valve considerably narrower than head valve, triangular,

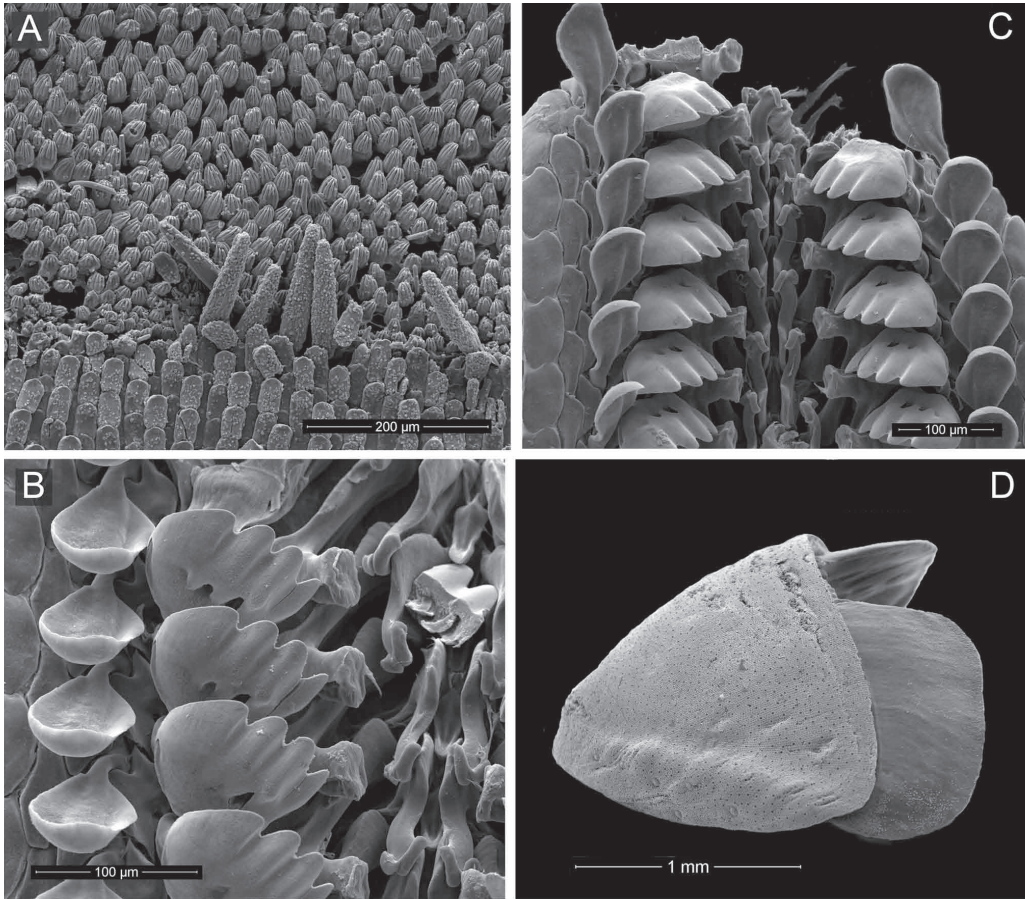


Fig. 12. *Onithochiton helenae vietnamensis* Sirenko subsp. nov., **holotype**, BL 13.0 mm, Vietnam, near Da Nang, rocky intertidal, on barnacles; **A** – dorsal, marginal and ventral scales and needles; **B**, **C** – radula; **D** – valve VIII, lateral view.

the length almost half the width, front margin straight, hind margin angularly rounded, anterior slope slightly convex, mucro almost terminal, tegmentum smooth, except for three small longitudinal pits along diagonal line per each side.

Articulamentum white with light brown in the middle and four brown narrow radial lines from apex to sides, apophyses well rounded, separated by wide finely pectinated sinus, insertion plates of head and intermediate plates slightly pectinated. Slit formula 8/1/0 (callus), slit rays well indicated.

Girdle about 1.4 mm wide near valve V, dorsally covered with short, thick, blunt-topped, distally sculptured spicules with 5 sharp riblets, 43x25 μm in the middle and 23x10 μm near margin, among them randomly dispersed small needle-like spicules, 62x7 μm . Marginal spicules long, round-topped, 130–150x21–22 μm .

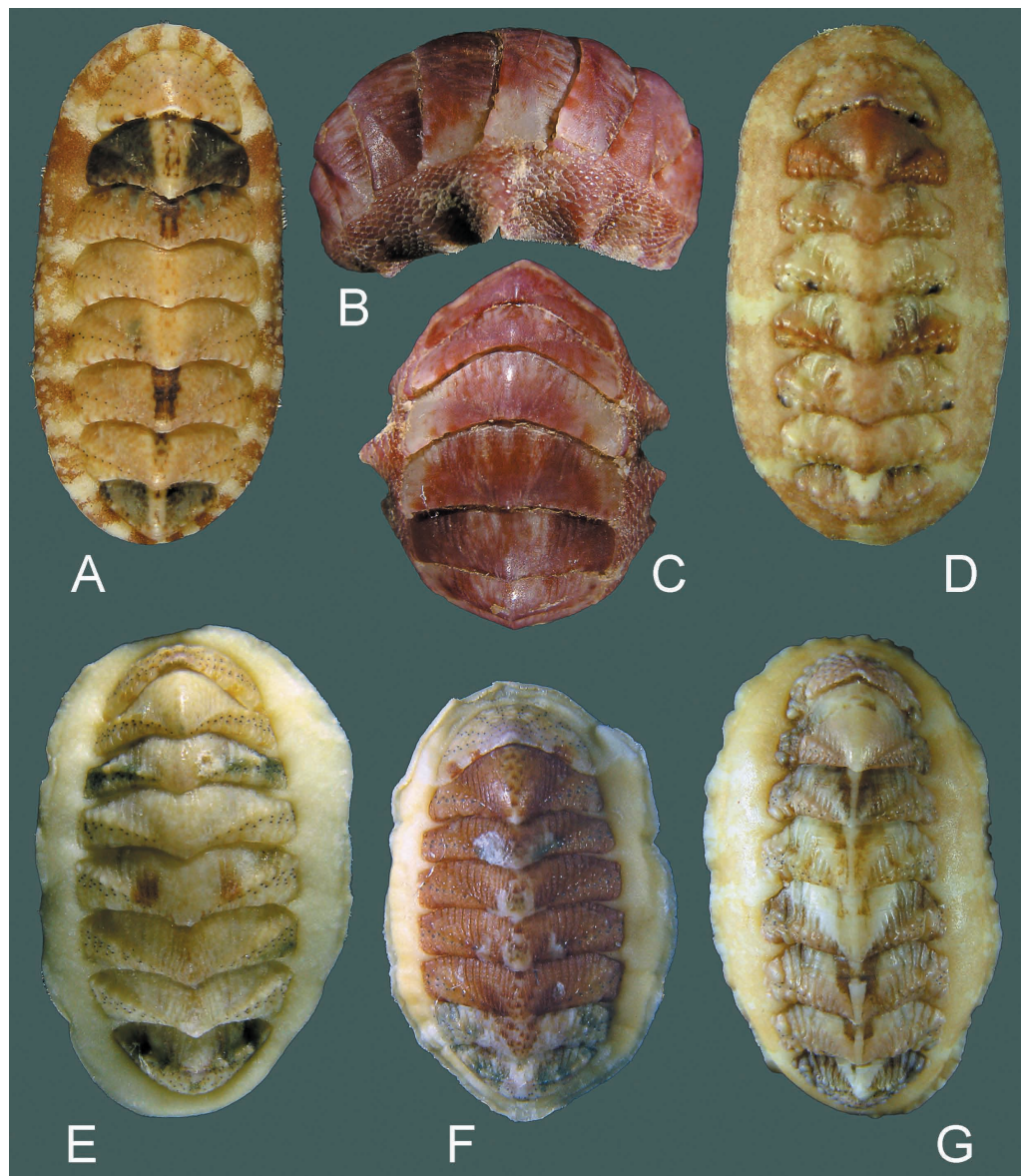


Fig. 13. Color images of species of genera *Rhyssopolax*, *Lucilina* and *Onithochiton* from Vietnam; **A** – *Onithochiton helenae vietnamensis* Sirenko subsp. nov., **holotype**, BL 13.0 mm, Vietnam, near Da Nang, rocky intertidal, on barnacles, 16.05.2012; **B, C** – *Rhyssopolax* cf. *maldivensis*, BL 13.5 mm, Vietnam, Shon Cha Is., 10 m, on bivalve shells, 20.04.2013; **D** – *Lucilina tenuicostata* Sirenko sp. nov., BL 10.0 mm, Vietnam, Gulf of Tonkin, Cat Ba Is., 5–6 m, SCUBA, on shells of *Pinna* spp. and *Isognomon* sp., 01.05.2012; **E, F** – *Lucilina* cf. *sowerbyi*, BL 10.1 mm (**E**) and 9.0 mm (**F**), Vietnam, Cau Is., 12–17 m, SCUBA, on bivalve shells, 06.05.2011; **G** – *Lucilina tenuicostata* Sirenko sp. nov., BL 12.0 mm, Vietnam, Gulf of Tonkin, Cat Ba Is., 2–4 m, SCUBA, on shells of *Isognomon* sp., 03.05.2012.

Ventral side of girdle covered with more or less rectangular smooth scales with slightly rounded tops, 28–40x25–28 μm .

Radula of the holotype 3.7 mm long with 36 transverse rows of mature teeth, central tooth somewhat pinched in the middle, first lateral tooth twice longer than central tooth, major lateral tooth with tetracuspoid blade.

The holotype with 25 gills on both sides, extending from valve III to valve VII.

Remarks. *O. helenae vietnamensis* differs from other species of the genus in its smooth sculpture of tegmentum, short faintly pectinated insertion plates and smooth ventral scales. The new subspecies differs from the nominative subspecies in having faintly pectinated insertion plates on the intermediate valves, as well as on the head valve.

Discussion

One of the main features of the family Chitonidae is the pectinated teeth of the insertion plates. The teeth of most species belonging to the subfamily Tonicinae (*Tonicia*, *Lucilina* and *Onithochiton*) are long and so deeply pectinated that each plate ends in a needle point. Juveniles of the above mentioned genera have no pectination on their teeth of the insertion plates. Pectination occurs and becomes stronger with an increase in age. There are two small species of the subfamily (both subspecies of *O. helenae* and *Rapanuia disalvei* Dell'Angelo, Raines et Bonfitto, 2004), in which the degree of pectination in the insertion plates varies. *O. helenae vietnamensis* (BL 13 mm) has short, faintly pectinated insertion plates on both the head and the intermediate valves. *O. helenae helenae* (BL 11 mm) has the same pectination only on the teeth of the head valve. *R. disalvei* (BL 5.3 mm) has no pectination on the teeth of the insertion plates. This last feature was the cause for the creation of the new genus *Rapanuia* Dell'Angelo, Raines et Bonfitto, 2004 and even the subfamily Rapanuinae Dell'Angelo, Raines et Bonfitto, 2004 in the family Ischnochitonidae Dall, 1889 (Dell'Angelo et al., 2004). However, based on all other features except for the absence of pectination on the teeth of the insertion plates, *R. disalvei* belongs to the genus *Tonicia* of the family Chitonidae. I think the subfamily Rapanuinae and the genus *Rapanuia* are junior synonyms, respectively, for Chitoninae and *Tonicia*.

There are currently 22 species of the family Chitonidae in the fauna of Vietnam (see Table). The species diversity of the two genera *Rhyssoplax* (7 species) and *Lucilina* (8 species) is higher. It is necessary to mention a few questionable species, *Rhyssoplax burmana* and *R. cf. speciosa*. Both species were found in Halong Bay and off Cat Ba Is. by H. Strack (2003). I sampled near Cat Ba Is. at different depths and localities, and only two species of the genera *Rhyssoplax*, namely, *R. komaiana* (Is. et Iw. Taki, 1929) and *R. venusta*, were found there and were abundant. The first

List of the chitons of the family Chitonidae found in Vietnam

N	Species	1	2	3	4	5	6	7	8	9
1	<i>Tegulaplastax hululensis</i> (E.A. Smith, 1903)	+	+	+	+	+				+
2	<i>Rhyssoplax bullocki</i> Sirenko, 2012				+	+	+		+	+
3	? <i>Rhyssoplax burmana</i> (Carpenter in Pilsbry, 1893) (Halong Bay, Cat Ba Is. leg. H. Strack)							+		
4	<i>Rhyssoplax komaiana</i> (Is. et Iw. Taki, 1929)			+	+	+	+	+	+	+
5	<i>Rhyssoplax</i> cf. <i>maldivensis</i> (E.A. Smith, 1903)					+	+		+	+
6	<i>Rhyssoplax pulcherrima</i> (Sowerby, 1842)	+	+		+	+				+
7	? <i>Rhyssoplax</i> cf. <i>speciosa</i> (Nierstrasz, 1905) (Halong Bay, Cat Ba Is. leg. H. Strack)							+		
8	<i>Rhyssoplax venusta</i> (Hull, 1923)				+	+	+	+		+
9	<i>Acanthopleura loochoana</i> (Broderip et Sowerby, 1829)							+		+
10	<i>Acanthopleura spinosa</i> (Bruguier, 1792)	+								
11	<i>Acanthopleura tenuispinosa</i> (Leloup, 1939)	+								+
12	<i>Liolophura japonica</i> (Lischke, 1873)							+		+
13	<i>Lucilina carnosa</i> (Kaas, 1979)		+		+	+			+	+
14	<i>Lucilina dilecta</i> Thiele, 1911					+			+	+
15	<i>Lucilina lamellosa</i> (Quoy et Gaimard, 1835)		+	+		+				+
16	<i>Lucilina</i> cf. <i>sowerbyi</i> (Nierstrasz, 1905)				+	+				+
17	<i>Lucilina tenuicostata</i> Sirenko sp. nov.						+	+	+	+
18	<i>Lucilina</i> cf. <i>tilbrookii</i> (Milne, 1958)		+		+	+			+	+
19	<i>Lucilina</i> sp. 1		+						+	+
20	<i>Lucilina</i> sp. 2		+						+	+
21	<i>Onithochiton helenae vietnamensis</i> Sirenko subsp. nov.						+		+	+
22	<i>Onithochiton strackii</i> Sirenko, 2012			+	+	+	+		+	+
Total		4	7	4	10	13	7	7	11	19

Notes. Localities: 1 – Phu Quoc Is.; 2 – Con Dao Archipelago; 3 – Phu Quy Is.; 4 – Cau Is.; 5 – Nha Trang Bay, Hon Dat; 6 – Da Nang, Shon Cha, Cu Lao Cham Is.; 7 – Hon Me, Cat Ba Is., Van Don; 8 – first find for Vietnam; 9 – studied by the author.

of these species, *R. komaiana*, is similar to *R. burmana* and the second one, *R. venusta*, is very similar to *R. speciosa*. Because of this connection, it is necessary to check the specimens of these two species collected by H. Strack. In order to clarify any doubts about the identification of *Rhyssoplax* cf. *maldivensis*, *Lucilina* cf. *sowerbyi*, and *L. cf. tilbrooki*, it is necessary to examine the types of these species. The exact identifications of *Lucilina* sp. 1 and *Lucilina* sp. 2 would be possible after these animals are collected whole.

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